APPENDIX B
FLOW MEASUREMENT TECHNICAL MEMORANDUM

CITY OF CARLSBAD

FLOW MEASUREMENT TM

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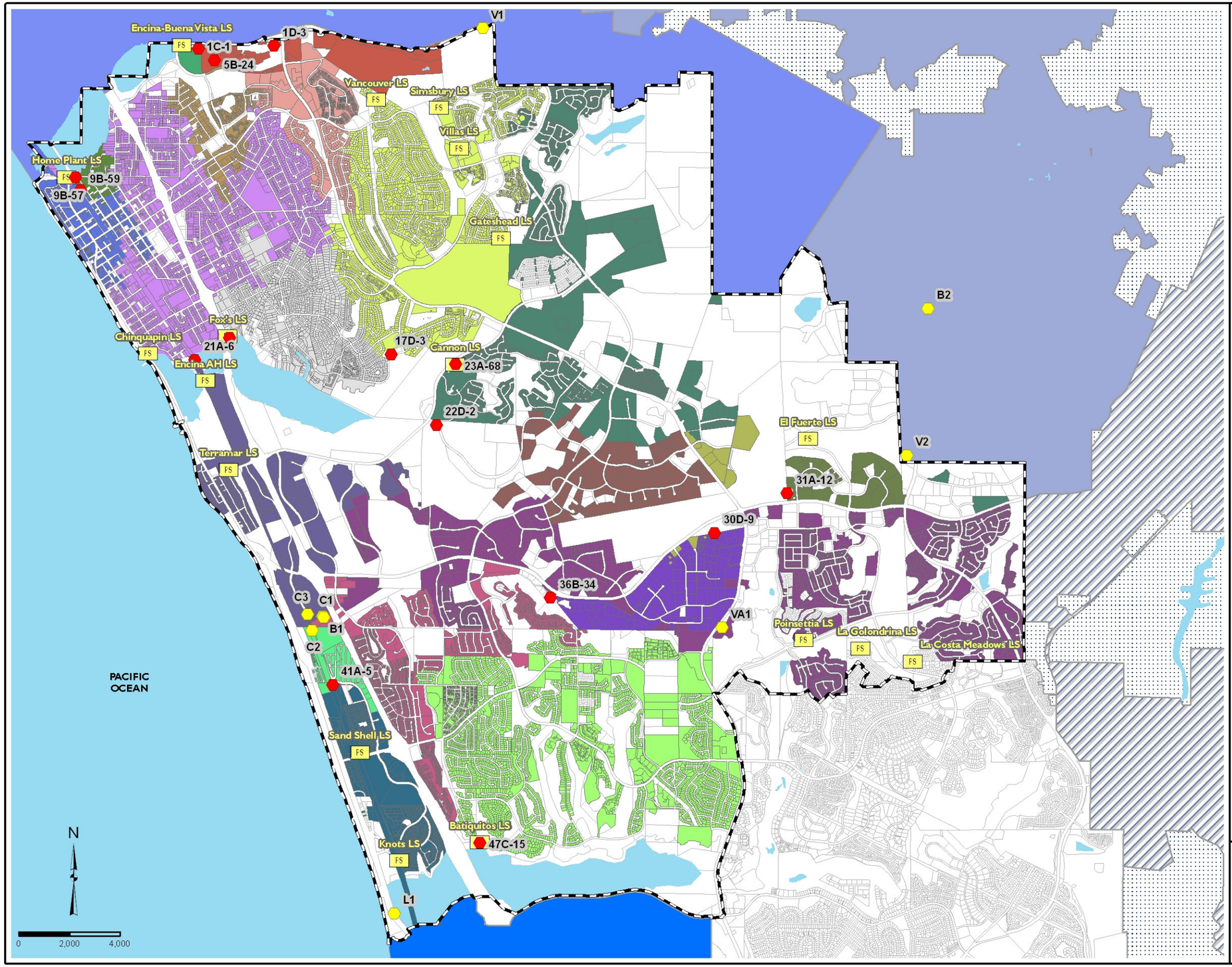
Background and Introduction

In February 2009, the City of Carlsbad measured flow at 15 temporary key locations in the sanitary sewer collection system. Additionally flow is permanently measured at 5 locations coming into the City and 3 locations exiting the system. Since the flow measurements made at the permanent sites are used to determine Carlsbad's billing and financial participation in the Encina Wastewater Agency's regional facilities they were considered the reference standard. A map showing the location of all flow metering locations is shown in Figure 1.

The flow measurements from all sites was analyzed to determine (1) To characterize the average dry day flows (2) to determine the quantity and location of additional defect flows from rainfall induced inflow and infiltration (3) to prioritize the location of additional field investigation of inflow and infiltration defects and (4) to support dry and wet weather hydraulic modeling in support of the Sewer Master Plan Update (2009).

This Technical Memorandum presents the 2009 flow measurement findings and the technical basis of analysis. Additional analyses was performed to determine the flow generation factors for major land uses based on sewer flow measurements and water billing records.

This Technical Memorandum is organized by presenting the overall findings of the Inflow and Infiltration Analysis in the Executive Summary. Subsequent sections of the report detail the flow data analysis techniques and the findings for use in the hydraulic model. The hydraulic modeling is being performed to determine the capacity of the collection system under current and future, dry and wet weather conditions. The Capacity Analysis results and findings are described in the Master Plan .



Legend

- TEMPORARY FLOW METERS
- PERMANENT FLOW METERS
- FS LIFT STATIONS
- SEWER DISTRICT BOUNDARY
- WATER BODIES

FLOW METER

- 16D-12
- 17D-3
- 1C-1
- 1D-3
- 21A-6
- 22D-2
- 23A-68
- 30D-9
- 31A-12
- 36B-34
- 41A-5
- 47C-15
- 5B-24
- 9B-57
- 9B-59
- B1
- BVLS
- C1
- C2
- C3
- PARCELS NOT CONTRIBUTING SEWER FLOW

NEIGHBORING CITIES

- ENCINITAS
- OCEANSIDE
- S.D. COUNTY
- SAN MARCOS
- VISTA

FIGURE I

CITY OF CARLSBAD FLOW MONITORING LOCATIONS AND BASINS

Executive Summary

Permanent flow meters, installed at 8 locations, continually measure flow into and out of the Carlsbad wastewater collection system. Temporary flow measurements were made at 15 different locations in February 2009. The combined flow measurements were used to characterize and quantify dry and wet weather flows. The analysis provides a basis for the calibration of the hydraulic model and for the prioritization of further I/I reduction related field investigations. The flow measurement locations and the tributary basins are shown in Figure 1.

Findings

1. Sufficient flow measurement information was available to characterize the Average Dry Weather Flow
2. Sufficient rainfall occurred during the flow measurement period to allow analysis of the systems response to rainfall.
3. Sufficient wet weather responses were analyzed to quantify the wet weather impact on the collection system.
4. Each area that flows to a particular flow meter (sub-basin) was ranked according to its observed unit defect flow.
5. While both inflow and infiltration responses were observed during the flow measurement period, inflow responses were dominant.
6. Considering the entire Carlsbad collection system, inflow and infiltration (I/I) observed during the flow measurement period is rated non-excessive by EPA Standards (1985).
7. Specific areas of the collection system require additional physical inspection and condition assessment to reduce their contributions to inflow and infiltration.

Recommendations

To further reduce inflow and infiltration in the highest ranked areas, additional physical inspection using CCTV, dye tracing, smoke testing and flow measurements should be performed. This would include the sub-basins along the Vista Carlsbad Interceptor and the Buena Vista Interceptor. The following Table 1 lists the observed defect flow rates for the top five basins with the highest unit defect flow. The table is ordered from most severe defect flow to least severe.

Table 1 Top 5 Net Unit Defect Flows

Net Unit Defect Flow		Defect Flow Volumes	
Rank	Site ID	Inflow-24hr. (gal/foot/in.)	Infil-72hr. (gal/foot/in.)
1	1C-1*	20.51	46.66
2	36B-34	8.31	16.49
3	B1	4.40	4.88
4	C-3*	2.04	10.68
5	22D-2	1.80	2.50
* Downstream locations - High 72hr. response			

Current CCTV operations should be modified to address the areas of highest concern first. Current CCTV inspections should be augmented with dye tracing to identify potential cross connections with the storm sewers and to positively identify and document roof drain and lateral connections with high inflow potential.

The following Figure 2 indicates graphically where the highest priority areas are located.

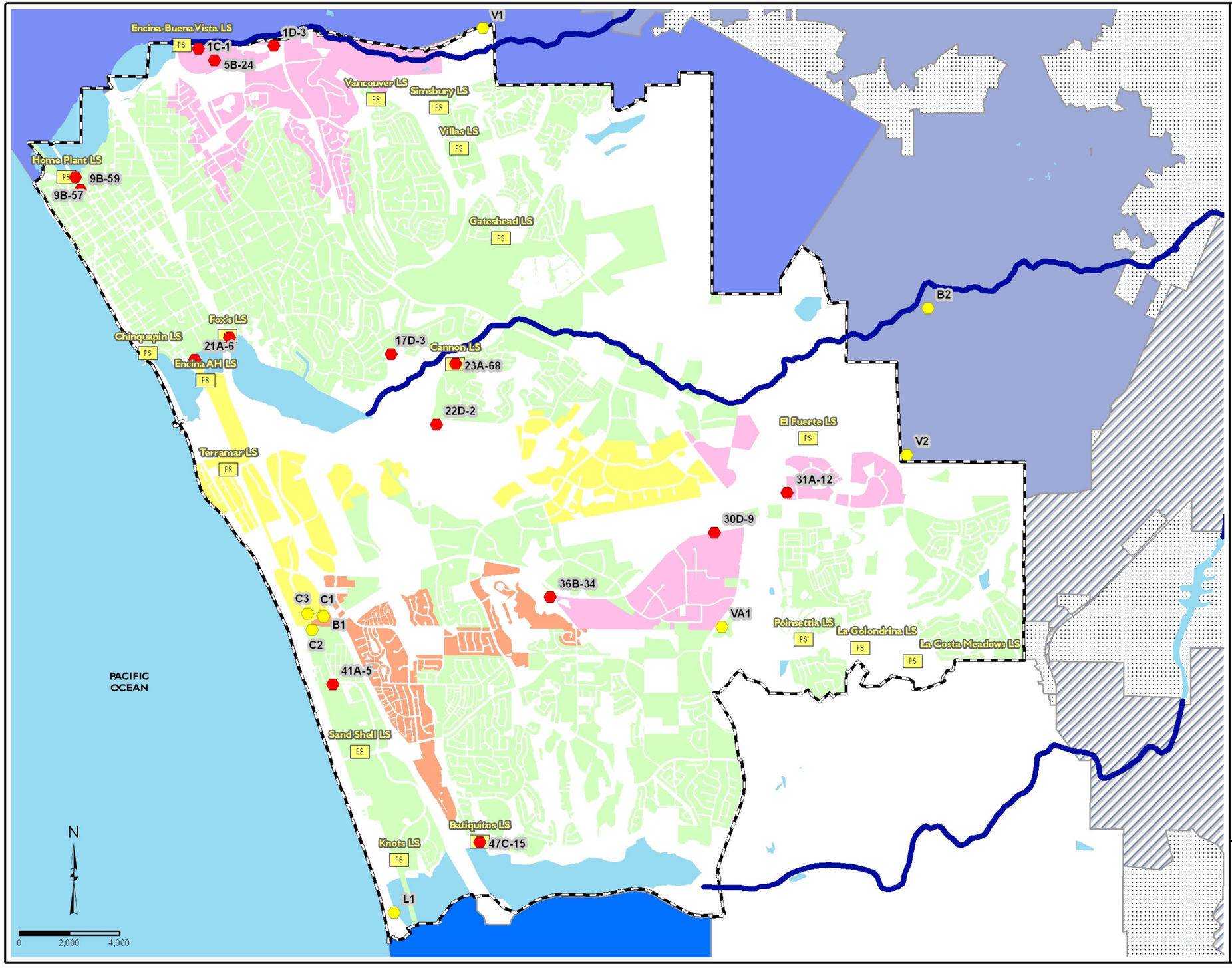


FIGURE 2

CITY OF CARLSBAD PRIORITY DEFECT FLOW BASINS

An estimated cost was prepared for each of the three primary work locations. The following Table 2 outlines these estimates which provide the basis of modification to the O&M budget. It is anticipated that all work would be performed by staff or by smaller contracts. No additional costs are included for detailed engineering analysis and preparation of rehabilitation program design. It is anticipated that these costs will be further developed through discussion with staff for inclusion in the Sewer Master Plan Update.

Table 2 Condition Assessment Cost Estimates

		Upper Vista/Carlsbad			Buena			Lower Vista/Carlsbad		
		From BVPS	To V1		From B1	To B2/V2		From C3	To 21A-6	
Method	Unit Cost*	Units		Estimated Cost	Units		Estimated Cost	Units		Estimated Cost
Smoke	0.75	96,652	$	72,489	128,974	$	96,730	246,649	$	184,987
MH Inspection	250	489	$	122,250	595	$	148,750	1014	$	253,500
CCTV Inspection	1.5	96,652	$	144,978	128,974	$	193,461	246,649	$	369,973
Dye Testing (25%)	175	122	$	21,350	148	$	25,900	253	$	44,275
Total of All	**$ 1,678,642**	Sub-Total	$	361,067	Sub-Total	$	464,841	Sub-Total	$	852,735

* Estimated commercial costs for comparison and budgeting only (to be performed by O&M staff)

Data Analysis Techniques and Findings

Analysis Period

The flow measurement period is defined by the shortest record available for any single flow meter. The temporary flow measurement devices were installed on February 4th, and 5th 2009 and remained in place until March 8th, 2009. Since only trace rainfall occurred during March, the period of flow data analysis for both the permanent and temporary flow data was from 5 Feb – 28 Feb, 2009.

Rainfall Analysis

To establish the overall hydraulic characteristics of the collection system, flow data is collected in wet and dry conditions. The analysis process included definition of a typical dry day for each site. A dry day is defined as a day on which no rainfall fell or there are no lingering results of prior rainfall. The selection of the dry days depends on observed rainfall measurements and observations of variance in the daily flow hydrographs. Rain gauge KCRQ, located at the Palomar Airport (33.1° N 117.3° W) was used in the determination of rainfall occurrence and amount in this analysis. The following Figure 3 and Table 3 describe the daily rainfall during the measurement period.

Figure 3 Carlsbad Rainfall February 2009

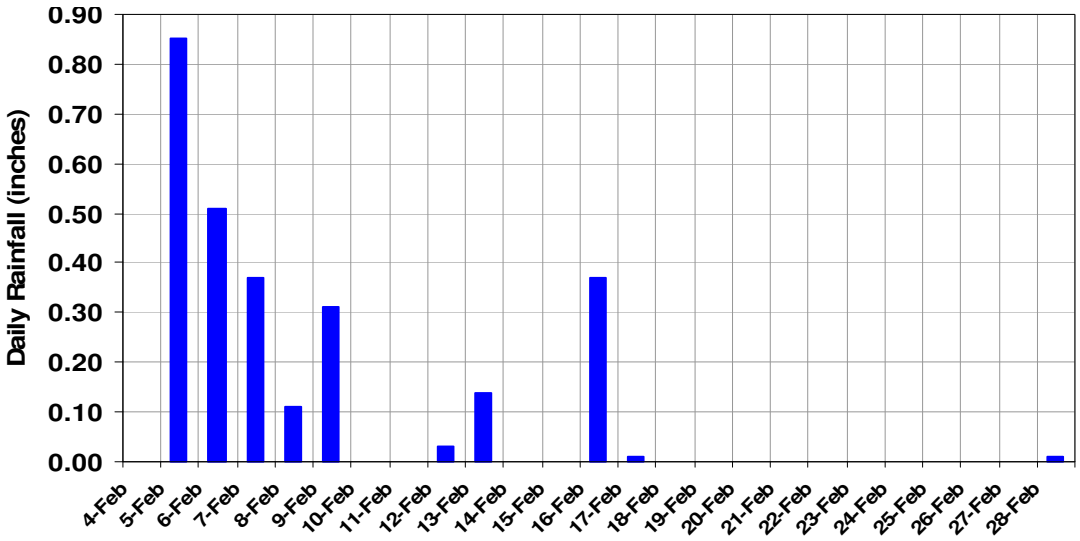


Table 3 Daily Rainfall Total Feb 2 - 28, 2009

Date	Total Rainfall (inches)
02/02/09	0
02/03/09	0
02/04/09	0
02/05/09	0.85
02/06/09	0.51
02/07/09	0.37
02/08/09	0.11
02/09/09	0.31
02/10/09	0
02/11/09	0
02/12/09	0.03
02/13/09	0.14
02/14/09	0
02/15/09	0
02/16/09	0.37
02/17/09	0.01
02/18/09	0
02/19/09	0
02/20/09	0
02/21/09	0
02/22/09	0
02/23/09	0
02/24/09	0
02/25/09	0
02/26/09	0
02/27/09	0
02/28/09	0.01
Total	**2.71**

Flow Measurement Sites

Two types of flow measurement instruments were used in the flow data analysis. The differences are described briefly below.

Permanent Installations

The permanent flow meters are installed and maintained by the Encina Wastewater Agency (EWA) through private contract. The permanent flow measurement locations isolate the Carlsbad collection system from its upstream and downstream to determine the flows from within the City and to provide a basis for the cost allocation at the Encina Wastewater Agency Treatment Plant and Regional Facilities. These facilities are regularly maintained and have been accepted as authoritative by the EWA member agencies.

Temporary Installations

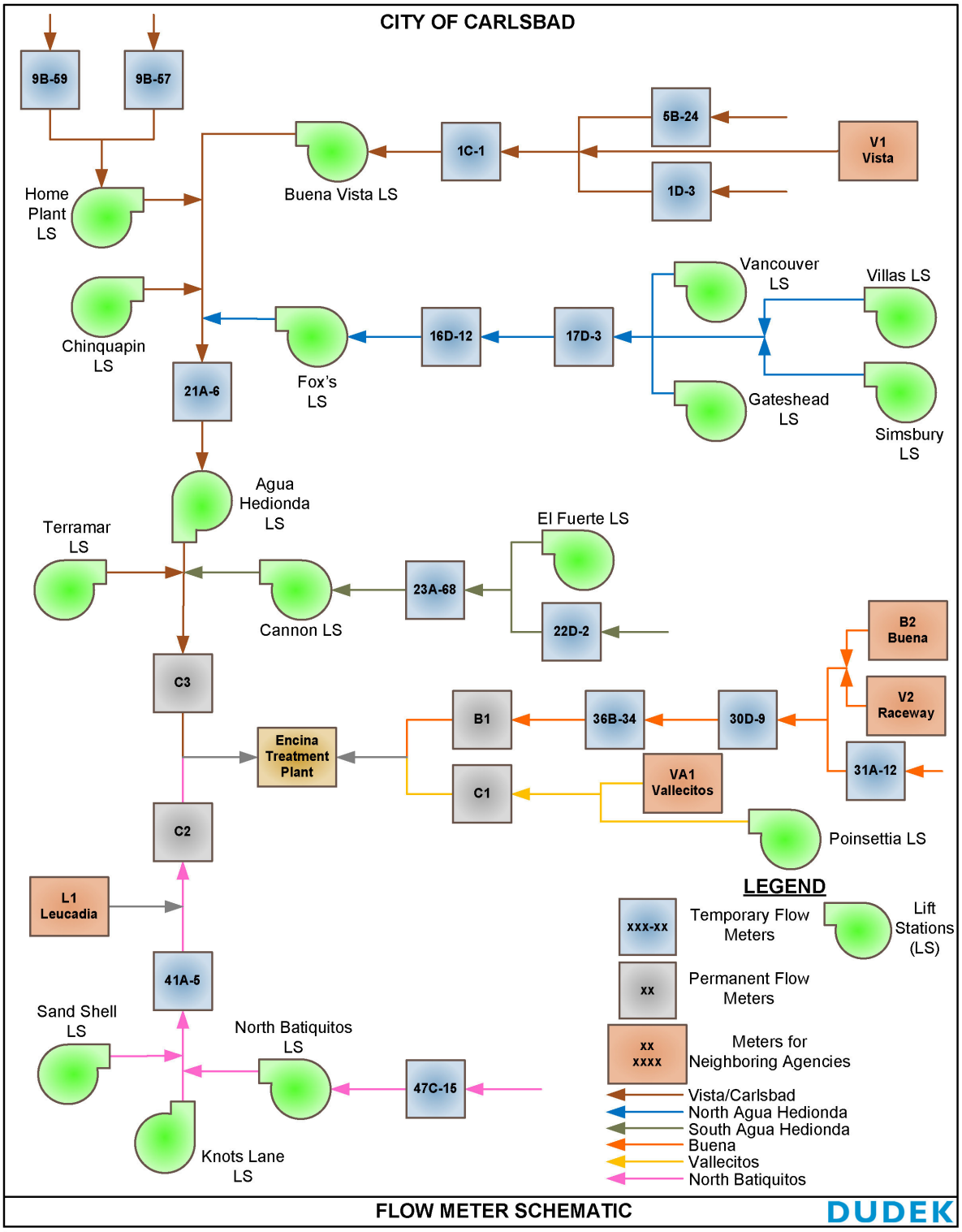
The temporary flow meters were installed at key location throughout the Carlsbad sewer collection system. These flow measurement devices were installed for approximately one month to provide a basis for flow allocation to smaller geographic areas. The temporary locations were installed, calibrated and regularly maintained throughout the measurement period. Since these flow measurement sites are widespread throughout the system they are subject to wider variations in accuracy due to lower depths and velocities than the permanent sites. Anomalous data from certain locations was not used in the analysis.

The location of the permanent and temporary locations is shown in Figure 1.

Total and Net Flow Definitions

To isolate flows within the collection system to smaller drainage areas or sub-basins, the concept of Total and Net Flows is defined. The flow measured at a site is the Total of all upstream flows. If there are no upstream flow measurements then the Net Flow is the same as the Total Flow. When there are upstream flow measurements, the flow that occurs between the upstream meter(s) and the downstream site is known as the Net Flow. This allows the area between the upstream meter(s) and the downstream site to be isolated and its flow characteristics defined separately. This process provides the basis of determining the location and sources of flows within the overall system. To properly assess the upstream and downstream positions, a flow schematic is prepared. This schematic simply shows the flow routing through the various flow measurement sites. Using the schematic, flows are then isolated by subtraction. The following Figure 4 shows these relationships for the Carlsbad collection system and the related permanent and temporary flow sites.

Figure 4 Flow Schematic



As shown, the permanent flow meter IDs that measure flow entering the City's collection system are V-1, V-2, B-2, VA-1 and L-1. Sites C1, C2 and C3 measure flow leaving the Carlsbad system. Site BVPS is located between sites C-3 and V-1 and is an internal permanent flow meter. The total flow at BVPS represents flows entering the system from Vista and Carlsbad. The total flow at V-1 represents flows entering the system from Vista. The Net flow at BVPS is calculated as the total flow at BVPS less the total flow at V1. This difference or net flow represents the flows entering the trunk system from Carlsbad along the upper reaches of the Vista/Carlsbad Interceptor.

Average Dry Weather Flow

Average Dry Weather Flow is calculated for each flow measurement site by averaging the flows for dry days. Dry days are defined as those days which rainfall did not occur and that there were no lingering effects of prior rainfalls. Due to the changes in flow volume and hourly variations between the weekdays (WD) and weekends (WE) these are characterized separately. Residential weekends are generally characterized with a later morning peak (1-2 hours) and with changes in daily volume. In industrial and office land use areas the normal peak and volume may be dramatically different in peak hourly use and in total volume. This is discussed at length in the description of flow generation factors.

Each day in the analysis period is reviewed for the occurrence of rainfall and for changes in the average hydrograph and is classified as Dry, NA or Event X. NA indicates a day that is not used in the analysis due to lingering effects of a rain event or to some other flow variation. An example of this in the current period was the occurrence of the President's Day holiday. Event X indicates a rainfall event that is used in the analysis to determine the volume and rate of defect flows. The ADWF flow is subtracted from the Event flow to determine the overall amount and rate of defect flows. The resulting defect flows are then further characterized by observing the relative magnitude of inflow and infiltration flows. The following Table 4 shows the classifications applied in the analysis.

Table 4 Day Classifications

Date	Rain Inches	Wx Class	Day	Day Class
2/2/09	0.00	Dry	Mon	Weekday
2/3/09	0.00	Dry	Tue	Weekday
2/4/09	0.00	Dry	Wed	Weekday
2/5/09	0.85	Wet_1	Thu	Weekday
2/6/09	0.51	Wet_1	Fri	Weekday
2/7/09	0.37	Wet_1	Sat	Weekend
2/8/09	0.11	Wet_1	Sun	Weekend
2/9/09	0.31	Wet_1	Mon	Weekday
2/10/09	0.00	Unc	Tue	Weekday
2/11/09	0.00	Unc	Wed	Weekday
2/12/09	0.03	Wet_2	Thu	Weekday
2/13/09	0.14	Wet_2	Fri	Weekday
2/14/09	0.00	Unc	Sat	Weekend
2/15/09	0.00	Unc	Sun	Weekend
2/16/09	0.37	Wet_3	Mon	Weekday
2/17/09	0.01	Wet_3	Tue	Weekday
2/18/09	0.00	Unc	Wed	Weekday
2/19/09	0.00	Unc	Thu	Weekday
2/20/09	0.00	Dry	Fri	Weekday
2/21/09	0.00	Dry	Sat	Weekend
2/22/09	0.00	Dry	Sun	Weekend
2/23/09	0.00	Dry	Mon	Weekday
2/24/09	0.00	Dry	Tue	Weekday
2/25/09	0.00	Dry	Wed	Weekday
2/26/09	0.00	Dry	Thu	Weekday
2/27/09	0.00	Dry	Fri	Weekday
2/28/09	0.01	Unc	Sat	Weekend
3/1/09	0.00	Dry	Sun	Weekend
3/2/09	0.00	Dry	Mon	Weekday
3/3/09	0.00	Dry	Tue	Weekday
3/4/09	0.00	Dry	Wed	Weekday
3/5/09	0.01	Unc	Thu	Weekday
Total	**2.72**			

Permanent Flow Measurement Site Results

For the dry days selected, all sites, permanent and temporary were characterized by determining the daily volume and the changes in hourly rate. The following tables show these with groupings for the incoming, internal and outgoing flow measurement sites. The permanent meter site dry weather analyses are shown followed by the temporary site analyses.

Table 5 Average Dry Weather Flow Weekdays

Flow Rate mgd	Incoming					Int.	Outgoing			
Hour	V1	V2	B2	VA1	L1	BVPS	B1	C1	C2	C3
0	4.906	0.260	1.931	4.906	4.668	6.076	3.038	6.284	5.414	10.828
1	3.487	0.264	1.399	4.049	3.551	4.937	2.416	5.188	4.290	9.085
2	2.611	0.252	1.104	3.018	2.718	4.010	1.859	4.167	3.051	7.105
3	2.017	0.267	0.970	2.392	2.406	3.458	1.563	3.263	2.639	5.411
4	1.908	0.262	0.926	2.088	2.393	3.188	1.495	2.873	2.402	4.414
5	1.810	0.320	0.953	1.955	2.261	3.024	1.470	2.565	2.375	3.887
6	2.083	0.256	1.300	2.007	2.387	3.225	1.557	2.627	2.759	3.762
7	3.451	0.333	2.410	2.556	3.697	4.004	2.524	3.211	4.611	4.273
8	6.291	0.465	3.576	5.085	7.964	6.218	4.240	5.659	9.348	6.991
9	6.732	0.522	3.312	7.728	8.486	7.458	4.893	8.623	9.753	11.351
10	6.219	0.572	3.008	7.772	7.550	7.099	4.470	9.248	8.713	13.119
11	6.063	0.669	2.867	7.122	6.961	6.741	4.330	8.547	8.307	12.456
12	6.118	0.584	2.721	6.841	6.313	6.755	4.128	8.295	7.303	11.919
13	5.910	0.571	2.556	6.369	5.845	6.655	3.982	7.748	6.950	11.621
14	5.798	0.573	2.505	5.793	5.495	6.418	3.864	7.255	6.440	11.264
15	5.732	0.602	2.413	5.721	5.222	6.347	3.799	6.900	6.252	10.757
16	5.582	0.566	2.337	5.321	5.134	6.312	3.610	6.607	5.930	10.542
17	5.689	0.501	2.423	4.983	5.138	6.303	3.473	6.274	5.853	10.136
18	6.129	0.452	2.661	5.017	5.307	6.538	3.574	6.167	6.408	10.354
19	6.479	0.392	2.951	5.406	6.137	7.062	3.784	6.548	7.066	10.747
20	6.915	0.358	3.172	6.325	6.731	7.367	4.067	7.571	8.195	11.904
21	6.929	0.325	3.098	6.796	6.914	7.539	3.976	8.162	8.117	12.286
22	6.572	0.310	2.846	6.725	6.377	7.301	3.821	8.067	7.405	12.469
23	5.951	0.299	2.441	5.826	5.543	6.787	3.397	7.216	6.504	11.874
Total Day Volume mg	**5.058**	**0.416**	**2.328**	**5.075**	**5.217**	**5.867**	**3.305**	**6.211**	**6.087**	**9.523**

Average Dry Weekday Total flows from Carlsbad = 7.033 mgd

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The following tables show the ADWF-WD Net Flows for each of the permanent metering sites. This breaks the flows down into major interceptors or upstream contributors and shows the percentage of flow allocated to each entity.

Vista Carlsbad Interceptor

Table 6 shows the average hourly flows along the Vista Carlsbad Interceptor between sites V1 incoming from Vista and C3 exiting Carlsbad and entering the EWA treatment facility. The calculations are discussed below.

Table 6 Vista Carlsbad Interceptor Flows ADWF WD

Flow Rate MGD Hour	Vista In V1	Total BVPS	BV-V1 BV_Net	Total C3	Net C3-BV	Net C3+BV
0	4.906	6.076	1.170	10.828	4.752	5.922
1	3.487	4.937	1.450	9.085	4.149	5.599
2	2.611	4.010	1.399	7.105	3.095	4.494
3	2.017	3.458	1.441	5.411	1.954	3.394
4	1.908	3.188	1.280	4.414	1.226	2.506
5	1.810	3.024	1.214	3.887	0.863	2.077
6	2.083	3.225	1.142	3.762	0.538	1.679
7	3.451	4.004	0.553	4.273	0.268	0.822
8	6.291	6.218	-0.073	6.991	0.772	0.699
9	6.732	7.458	0.727	11.351	3.893	4.620
10	6.219	7.099	0.880	13.119	6.019	6.900
11	6.063	6.741	0.678	12.456	5.714	6.393
12	6.118	6.755	0.637	11.919	5.165	5.801
13	5.910	6.655	0.745	11.621	4.966	5.711
14	5.798	6.418	0.620	11.264	4.847	5.466
15	5.732	6.347	0.615	10.757	4.411	5.026
16	5.582	6.312	0.730	10.542	4.231	4.961
17	5.689	6.303	0.614	10.136	3.833	4.447
18	6.129	6.538	0.409	10.354	3.816	4.225
19	6.479	7.062	0.582	10.747	3.685	4.267
20	6.915	7.367	0.452	11.904	4.537	4.989
21	6.929	7.539	0.609	12.286	4.747	5.356
22	6.572	7.301	0.728	12.469	5.168	5.897
23	5.951	6.787	0.836	11.874	5.087	5.923
Total MG	**5.058**	**5.867**	**0.810**	**9.523**	**3.656**	**4.466**

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The flows enter this interceptor from Vista at permanent site V1 where they flow west to the Buena Vista Pump Station located near Jefferson Street at Highway 78. The pump station has a permanent flow meter BVPS that is considered an internal meter to Carlsbad. Subtracting the BVPS flows from the V1 flows calculates the flows from Carlsbad that are contributed along the upper reaches of the Vista/Carlsbad interceptor. At the Encina treatment plant, permanent flow meter C-3 measures the total flows upstream which includes additional flow from Carlsbad. Subtraction of the C3 Total flows from the BVPS Total flows yields the Net C3 Flows which is the flow that Carlsbad contributes between the BVPS and C3 Sites. In the upper reaches of the VC Interceptor, Vista contributes 5.05 mgd of flow to the total 5.86 mgd measured at the BVPS site. This indicates that Vista contributes 86% of the total flow with Carlsbad contributing the other 14%. At the C3 site, Vista would contribute 5.05 mgd of the total 9.523 mgd or 53% of the total flow. Between BVPS and C3, Carlsbad adds 3.66 mgd. The total Carlsbad flow contribution along the trunk between V1 and C3 is 4.466 mgd.

Buena Vista Interceptor

Table 7 shows the average hourly flows along the Buena Vista Interceptor between sites V2 and B2 incoming from Vista and B1 exiting Carlsbad and entering the EWA treatment facility. The calculations are discussed below.

Table 7 Buena Vista Interceptor ADWF WD

	Vista In	Out	Cbd
Hour	B2+V2	B1*	B1_Net
0	2.191	2.416	0.225
1	1.663	1.859	0.196
2	1.357	1.563	0.207
3	1.237	1.495	0.258
4	1.187	1.470	0.282
5	1.274	1.557	0.283
6	1.556	2.524	0.968
7	2.742	4.240	1.497
8	4.041	4.893	0.852
9	3.834	4.470	0.637
10	3.580	4.330	0.750
11	3.536	4.128	0.592
12	3.306	3.982	0.676
13	3.127	3.864	0.737
14	3.078	3.799	0.721
15	3.016	3.610	0.595
16	2.902	3.473	0.571
17	2.924	3.574	0.650
18	3.114	3.784	0.670
19	3.343	4.067	0.725
20	3.531	3.976	0.445
21	3.422	3.821	0.398
22	3.156	3.397	0.241
23	2.741	3.038	0.297
Total MG	**2.744**	**3.305**	**0.561**

The total flows from Buena and Raceway pump stations in Vista are from permanent sites B2 and V2 respectively. The total flow from these stations was 2.744 mgd for the ADWF – WD flows. The flows leaving the Carlsbad system and entering the EWA facility are measured at site B1. The ADWF – WD flows here were observed to be 3.305 mgd during the monitoring period. The difference between these flows is 0.561 mgd which is Carlsbad's contribution along the Buena Vista Interceptor. This indicates that Carlsbad is currently contributing approximately 17% of the total flow in the interceptor while Vista and the Buena Sanitation District are contributing the remaining 83%. The peak diurnal variation between Sites B1 and

B2+V2 are offset by one hour. To clarify the analysis the hourly flow rates at these sites were offset to match peak flow rates.

Vallecitos Interceptor

Table 8 shows the average hourly flows along the Vallecitos Interceptor between sites VA1 incoming from Vallecitos and C1 exiting Carlsbad and entering the EWA treatment facility. The calculations are discussed below.

Table 8 Vallecitos Interceptor ADWF WD

Hour	VMWD VA1	Out C1	CBD Net C1
0	4.906	6.284	1.379
1	4.049	5.188	1.140
2	3.018	4.167	1.149
3	2.392	3.263	0.871
4	2.088	2.873	0.785
5	1.955	2.565	0.610
6	2.007	2.627	0.620
7	2.556	3.211	0.655
8	5.085	5.659	0.574
9	7.728	8.623	0.895
10	7.772	9.248	1.476
11	7.122	8.547	1.425
12	6.841	8.295	1.455
13	6.369	7.748	1.380
14	5.793	7.255	1.462
15	5.721	6.900	1.180
16	5.321	6.607	1.285
17	4.983	6.274	1.291
18	5.017	6.167	1.150
19	5.406	6.548	1.142
20	6.325	7.571	1.246
21	6.796	8.162	1.366
22	6.725	8.067	1.343
23	5.826	7.216	1.390
Total MG	**5.075**	**6.211**	**1.136**

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The ADWF flows measured at the VA1 site are discharged from the Vallecitos MWD site were observed to be 5.07 mgd during the flow measurement period. The flows exiting the Carlsbad service area and entering the EWA treatment facility were measured at site C1. The ADWF flows were 6.211 mgd. The difference between these readings indicates a contribution from Carlsbad of 1.136 mgd during an average dry weekday. This indicates that Carlsbad contributes

approximately 18% of the total flow during the period of analysis while Vallecitos contributed the remaining 82%. A separate discussion of the inflow and infiltration observations on the Vallecitos system will be found in the wet weather analysis portion of this document.

Leucadia/Carlsbad Interceptor

Table 9 shows the average hourly flows along the Leucadia/Carlsbad Interceptor between sites L1 incoming from Leucadia and C2 exiting Carlsbad and entering the EWA treatment facility. The calculations are discussed below.

Table 9 Leucadia/Carlsbad Interceptor

Hour	LCWD	Out	Net
	L1	C2	C2
0	4.668	5.414	0.746
1	3.551	4.290	0.739
2	2.718	3.051	0.333
3	2.406	2.639	0.233
4	2.393	2.402	0.009
5	2.261	2.375	0.114
6	2.387	2.759	0.373
7	3.697	4.611	0.914
8	7.964	9.348	1.384
9	8.486	9.753	1.267
10	7.550	8.713	1.162
11	6.961	8.307	1.346
12	6.313	7.303	0.990
13	5.845	6.950	1.105
14	5.495	6.440	0.945
15	5.222	6.252	1.031
16	5.134	5.930	0.796
17	5.138	5.853	0.714
18	5.307	6.408	1.101
19	6.137	7.066	0.930
20	6.731	8.195	1.464
21	6.914	8.117	1.203
22	6.377	7.405	1.028
23	5.543	6.504	0.961
Total MG	**5.217**	**6.087**	**0.870**

101.Engineering\Carlsbad\6251 Sewer Master Plan\6-Design Data\Encina flow data\Noah_Work_Area\[Encina_Hourly.xls]ptWxDaySite

Flows from the Leucadia Wastewater District are measured entering the Carlsbad system at site L1. The average dry weather weekday flows were calculated as 5.217 mgd at this site. The combined flows from Carlsbad and Leucadia are measured leaving the system and entering the EWA treatment facility at site C2 and were calculated as 6.087 mgd. Carlsbad's contribution

was found by the difference between the two sites and is 0.870 mgd during the measurement period. This indicates that Leucadia CWD contributes 86% of the dry weather flow while Carlsbad contributes the remaining 14%.

Total Carlsbad ADWF WD

The following Table 10 combines the net Carlsbad flows at each monitoring point to determine the total dry day flows from Carlsbad and the percent of flow contributed along each interceptor. Most of the Carlsbad flows in the system occurs upstream of the C3 monitoring site. As shown the average dry weekday flow contribution for Carlsbad during the selected dry weather weekdays was 7.033 mgd.

Table 10 Total Combined Carlsbad Flows

Combined Carlsbad Net Flows					
Hour	C3BV Net	B1_Net	Net C1	Net C2	Total
0	5.922	0.225	1.379	0.746	8.272
1	5.599	0.196	1.140	0.739	7.674
2	4.494	0.207	1.149	0.333	6.183
3	3.394	0.258	0.871	0.233	4.756
4	2.506	0.282	0.785	0.009	3.582
5	2.077	0.283	0.610	0.114	3.084
6	1.679	0.968	0.620	0.373	3.640
7	0.822	1.497	0.655	0.914	3.888
8	0.699	0.852	0.574	1.384	3.510
9	4.620	0.637	0.895	1.267	7.418
10	6.900	0.750	1.476	1.162	10.288
11	6.393	0.592	1.425	1.346	9.756
12	5.801	0.676	1.455	0.990	8.922
13	5.711	0.737	1.380	1.105	8.933
14	5.466	0.721	1.462	0.945	8.594
15	5.026	0.595	1.180	1.031	7.831
16	4.961	0.571	1.285	0.796	7.612
17	4.447	0.650	1.291	0.714	7.101
18	4.225	0.670	1.150	1.101	7.147
19	4.267	0.725	1.142	0.930	7.064
20	4.989	0.445	1.246	1.464	8.144
21	5.356	0.398	1.366	1.203	8.324
22	5.897	0.241	1.343	1.028	8.508
23	5.923	0.297	1.390	0.961	8.571
Total MG	**4.466**	**0.561**	**1.136**	**0.870**	**7.033**
	63%	8%	16%	12%	

101.Engineering\Carlsbad\6251 Sewer Master Plan\6-Design Data\Encina flow data\Noah_Work_Area\[Encina_Hourly.xls]ptWxDaySite

Temporary Flow Site Results

During the flow measurement period from 5 February to 8 March 2009, V&A installed and maintained 15 temporary sites within the Carlsbad collection system. V&A has presented the

data analysis in a separate document. The flows in the report do not consider the upstream flows from the permanent meters therefore additional analysis was required. This portion of the document focuses on the temporary results while the subsequent portion will discuss the results of the wet weather flow analysis and the integration of the data sources.

As shown in Figure 4 the temporary flow measurement sites were located to further subdivide the collection system. This is done so additional follow-on work for the isolation of defect flows can be directed to smaller areas of the collection system. The following Table 11 indicates the Average Dry Weather Weekday (ADWF – WD) flow for each of the temporary sites.

Table 11 Total ADWF WD Flow Temporary Sites

Hour	16D-12	17D-3	1C-1	1D-3	21A-6	22D-2	23A-68	30D-22	31A-12	36B-34	41A-5	47C-15	5B-24	9B-57	9B-59
0	0.950	0.329	4.908	0.250	7.481	0.111	0.795	1.889	0.025	1.856	0.977	0.479	0.035	0.140	0.225
1	0.764	0.249	3.796	0.189	6.008	0.114	0.684	1.567	0.027	1.435	0.732	0.362	0.025	0.136	0.177
2	0.645	0.228	2.987	0.184	4.813	0.081	0.599	1.312	0.031	1.226	0.570	0.287	0.020	0.130	0.159
3	0.589	0.213	2.693	0.166	4.162	0.073	0.556	1.163	0.029	1.124	0.485	0.267	0.020	0.124	0.138
4	0.572	0.217	2.556	0.154	3.879	0.087	0.583	1.108	0.027	1.140	0.445	0.259	0.023	0.127	0.132
5	0.587	0.281	2.683	0.238	3.841	0.103	0.683	1.386	0.027	1.318	0.487	0.321	0.027	0.132	0.168
6	0.753	0.673	3.174	0.466	4.634	0.116	0.988	2.393	0.047	2.042	0.674	0.684	0.089	0.168	0.277
7	1.298	1.161	5.042	0.633	7.086	0.163	1.415	3.879	0.071	4.003	1.337	1.218	0.173	0.184	0.457
8	1.773	0.969	6.893	0.595	9.981	0.248	1.378	3.889	0.112	4.449	1.900	1.224	0.149	0.183	0.492
9	1.570	0.846	6.975	0.564	10.443	0.378	1.403	3.431	0.142	4.007	1.834	1.096	0.122	0.183	0.492
10	1.476	0.751	7.045	0.553	9.860	0.431	1.369	3.272	0.152	3.899	1.736	1.024	0.107	0.179	0.490
11	1.309	0.679	7.091	0.512	9.597	0.453	1.348	3.141	0.144	3.684	1.632	0.926	0.096	0.186	0.504
12	1.232	0.625	7.090	0.482	9.426	0.437	1.304	2.953	0.143	3.514	1.500	0.836	0.090	0.179	0.475
13	1.225	0.563	6.830	0.461	9.226	0.398	1.249	2.816	0.136	3.352	1.391	0.805	0.077	0.178	0.439
14	1.111	0.530	6.738	0.444	8.867	0.427	1.229	2.666	0.148	3.273	1.340	0.756	0.076	0.180	0.453
15	1.061	0.514	6.630	0.432	8.716	0.421	1.225	2.618	0.127	3.144	1.255	0.745	0.076	0.177	0.418
16	1.056	0.541	6.528	0.473	8.517	0.379	1.201	2.610	0.098	3.064	1.225	0.745	0.076	0.181	0.399
17	1.108	0.627	6.674	0.503	8.770	0.329	1.230	2.691	0.074	3.227	1.233	0.781	0.089	0.181	0.446
18	1.200	0.734	7.140	0.543	9.325	0.253	1.224	2.929	0.051	3.434	1.340	0.900	0.108	0.176	0.460
19	1.327	0.814	7.461	0.550	9.918	0.183	1.210	3.310	0.035	3.798	1.543	1.062	0.124	0.178	0.461
20	1.396	0.840	7.679	0.537	10.239	0.165	1.225	3.319	0.023	3.841	1.601	1.057	0.118	0.175	0.432
21	1.378	0.751	7.487	0.504	10.206	0.149	1.152	3.001	0.025	3.548	1.576	0.898	0.105	0.170	0.418
22	1.279	0.640	6.798	0.454	9.610	0.129	1.034	2.569	0.021	3.120	1.435	0.814	0.081	0.159	0.376
23	1.136	0.491	6.042	0.367	8.757	0.122	0.887	2.165	0.016	2.540	1.212	0.637	0.057	0.152	0.302
Daily Volume	**1.116**	**0.594**	**5.789**	**0.427**	**8.057**	**0.240**	**1.082**	**2.587**	**0.072**	**2.918**	**1.227**	**0.758**	**0.082**	**0.165**	**0.366**

Table 12 Hourly Flow Factors TFM ADWF WD

Hour	16D-12	17D-3	1C-1	1D-3	21A-6	22D-2	23A-68	30D-22	31A-12	36B-34	41A-5	47C-15	5B-24	9B-57	9B-59
0	0.85	0.55	0.85	0.59	0.93	0.46	0.73	0.73	0.35	0.64	0.80	0.63	0.43	0.85	0.61
1	0.68	0.42	0.66	0.44	0.75	0.48	0.63	0.61	0.38	0.49	0.60	0.48	0.30	0.82	0.48
2	0.58	0.38	0.52	0.43	0.60	0.34	0.55	0.51	0.43	0.42	0.46	0.38	0.24	0.79	0.43
3	0.53	0.36	0.47	0.39	0.52	0.30	0.51	0.45	0.40	0.39	0.40	0.35	0.24	0.75	0.38
4	0.51	0.37	0.44	0.36	0.48	0.36	0.54	0.43	0.38	0.39	0.36	0.34	0.28	0.77	0.36
5	0.53	0.47	0.46	0.56	0.48	0.43	0.63	0.54	0.38	0.45	0.40	0.42	0.33	0.80	0.46
6	0.67	1.13	0.55	1.09	0.58	0.48	0.91	0.93	0.65	0.70	0.55	0.90	1.09	1.02	0.76
7	1.16	1.95	0.87	1.48	0.88	0.68	1.31	1.50	0.99	1.37	1.09	1.61	2.11	1.12	1.25
8	1.59	1.63	1.19	1.39	1.24	1.03	1.27	1.50	1.56	1.52	1.55	1.61	1.82	1.11	1.34
9	1.41	1.42	1.20	1.32	1.30	1.58	1.30	1.33	1.97	1.37	1.49	1.45	1.49	1.11	1.34
10	1.32	1.26	1.22	1.30	1.22	1.80	1.27	1.26	2.11	1.34	1.41	1.35	1.30	1.08	1.34
11	1.17	1.14	1.22	1.20	1.19	1.89	1.25	1.21	2.00	1.26	1.33	1.22	1.17	1.13	1.38
12	1.10	1.05	1.22	1.13	1.17	1.82	1.21	1.14	1.99	1.20	1.22	1.10	1.10	1.08	1.30
13	1.10	0.95	1.18	1.08	1.15	1.66	1.15	1.09	1.89	1.15	1.13	1.06	0.94	1.08	1.20
14	1.00	0.89	1.16	1.04	1.10	1.78	1.14	1.03	2.06	1.12	1.09	1.00	0.93	1.09	1.24
15	0.95	0.87	1.15	1.01	1.08	1.75	1.13	1.01	1.76	1.08	1.02	0.98	0.93	1.07	1.14
16	0.95	0.91	1.13	1.11	1.06	1.58	1.11	1.01	1.36	1.05	1.00	0.98	0.93	1.10	1.09
17	0.99	1.06	1.15	1.18	1.09	1.37	1.14	1.04	1.03	1.11	1.00	1.03	1.09	1.10	1.22
18	1.08	1.24	1.23	1.27	1.16	1.05	1.13	1.13	0.71	1.18	1.09	1.19	1.32	1.07	1.26
19	1.19	1.37	1.29	1.29	1.23	0.76	1.12	1.28	0.49	1.30	1.26	1.40	1.51	1.08	1.26
20	1.25	1.41	1.33	1.26	1.27	0.69	1.13	1.28	0.32	1.32	1.30	1.39	1.44	1.06	1.18
21	1.23	1.26	1.29	1.18	1.27	0.62	1.06	1.16	0.35	1.22	1.28	1.18	1.28	1.03	1.14
22	1.15	1.08	1.17	1.06	1.19	0.54	0.96	0.99	0.29	1.07	1.17	1.07	0.99	0.96	1.03
23	1.02	0.83	1.04	0.86	1.09	0.51	0.82	0.84	0.22	0.87	0.99	0.84	0.70	0.92	0.83
Check	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

The following graph shows each of the sites characteristic Hourly Flow Factor. This is found by dividing the ADWF-WD Hourly Average by the total volume for the day. This standardizes the hourly variations of flow regardless of the total daily volume. Inspection reveals that there the hydrographs can be categorized into predominately residential, non-residential and mixed classes.

Sites 31A-12 and 22D-2 are non-residential and represent the Loker and Faraday Business Parks respectively. These are broken out and displayed separately in the following charts.

Figure 5 Hourly Flow Factors All Temporary Sites

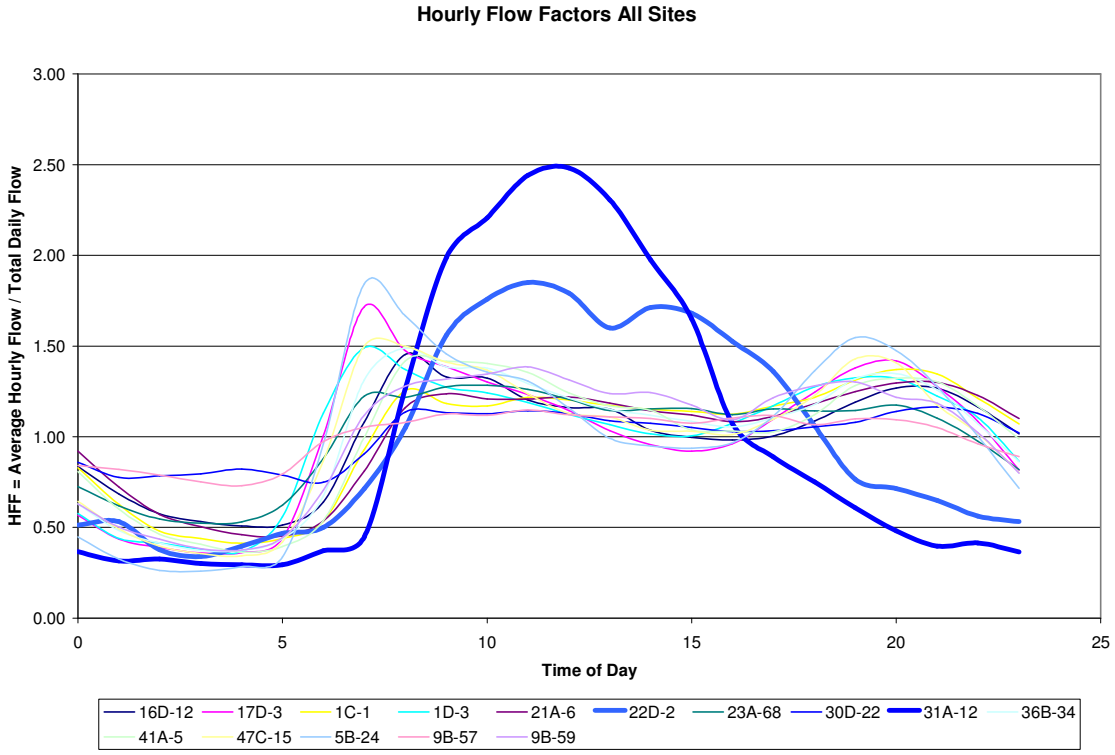
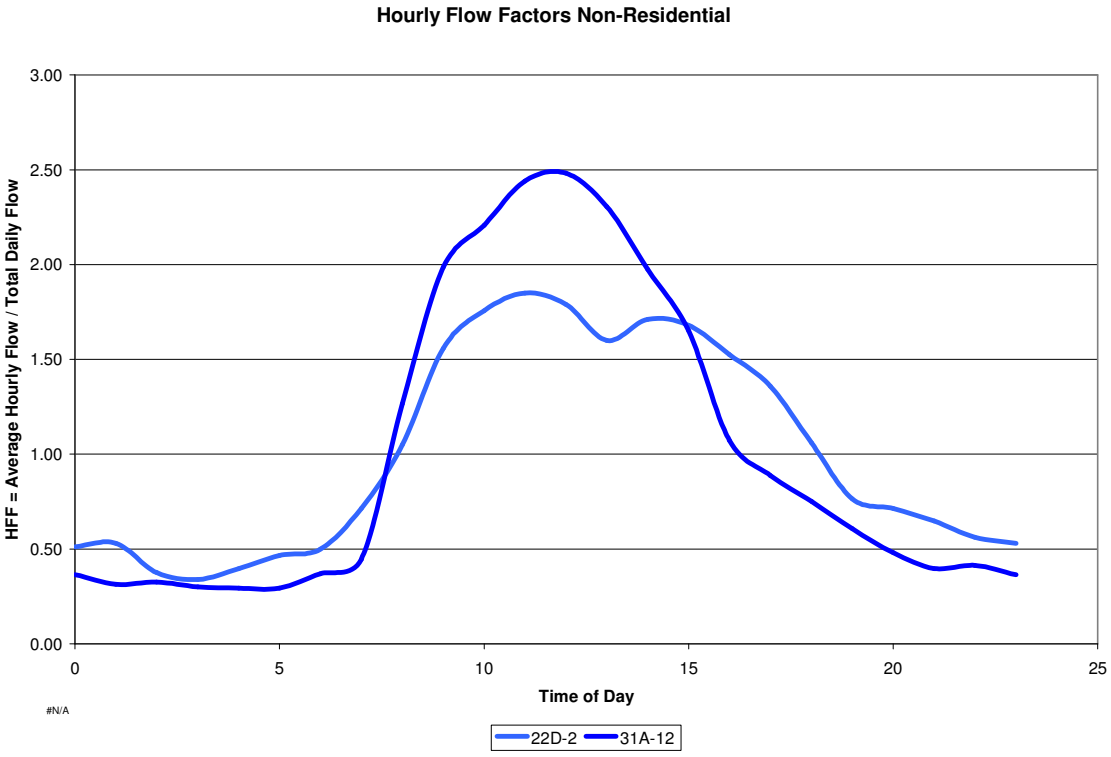


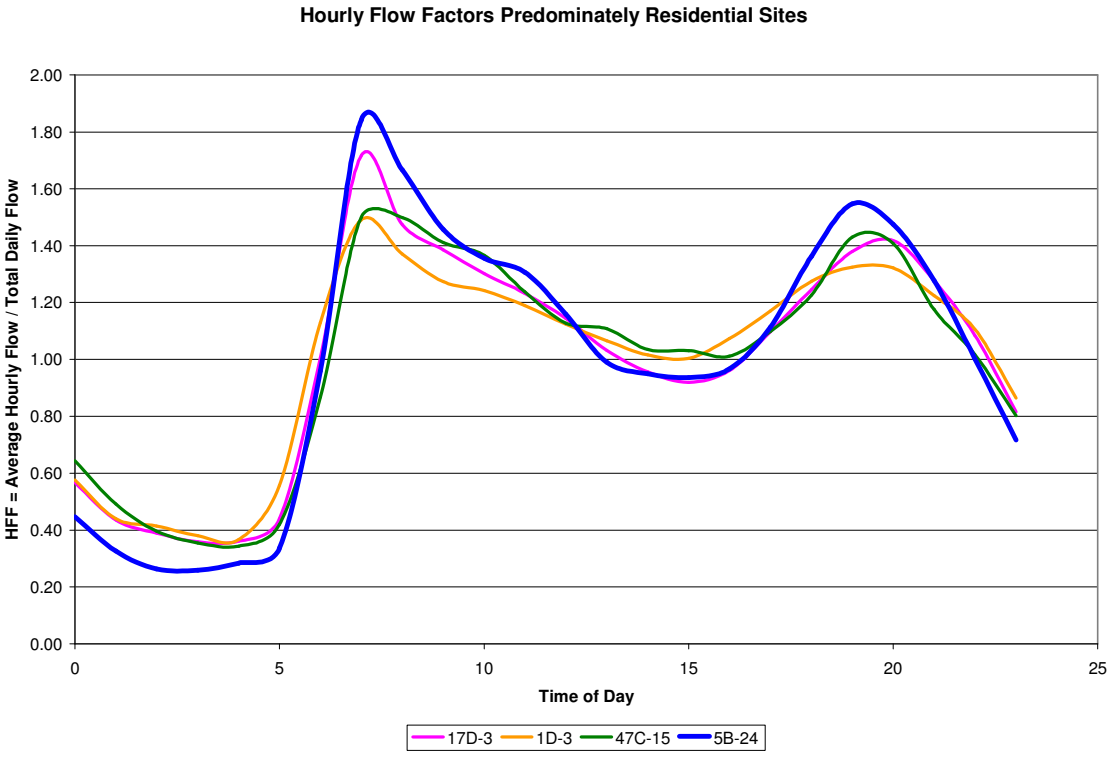
Figure 6 Loker and Faraday HFF ADWF WD



Site 22D-2 measures the flow from the Faraday Business Park while site 31A-12 measures the flow from the Loker Business Park. Flows from the Loker site were generally too low for accurate measurement due to the increased vacancy rate in the park. The site did provide good insight into the diurnal flow pattern at this location.

The following chart shows a selection of predominately residential hourly flow factors. Site 5B-24 has the highest peaking factor and is also the most homogenous residential land use. This site is used as the standard flow pattern for all residential loading. Note that this is a classic suburban residential flow pattern with an early morning and mid-evening peak.

Figure 7 Residential Hourly Flow Factors



These diurnal curves or flow patterns are dependent on the average daily flow rate. The temporary flow measurement sites have lower average daily flow rates and exhibit the greatest hourly flow factors. This comes from a combination of factors including (1) land use (2) pipe volume based flow attenuation and (3) attenuation from the timing effects of adding hydrographs. The model being prepared to evaluate the capacity of the collection system will be loaded with flow patterns from the upstream flow meters and calibrated to flow patterns observed at the long term meters.

Flow balancing

Flow or mass balancing is the flow data analysis process where upstream (net) and total flows are compared to assure that the flows are consistent, Referring to the flow schematic in Figure 4 the following topological relationships are defined for each of the major branches in the system.

The process of mixing flow readings from different installations (permanent and temporary) leads to certain imbalances due to a variety of reasons. A review of the flow balancing and the operational characteristics of each monitor resulted in the elimination of four of the fifteen monitors. These monitors typically had flows that were too low in depth and/or velocity to be accurately measured. All revisions and eliminations were based on reliance that the permanent flow meters were accurate and well maintained.

In two of the sites retained, a five percent increase in total Average Dry Day Flow. This increase in flow was applied at site 21A-6 and 36B-34 to achieve flow balance with the downstream permanent installations.

Findings (Revised)

Based on the findings of the complete review of the draft date the final table that was considered for the location and amount of inflow and infiltration is found in the following Table 13. These are keyed to the color and order of the system schematic for ease of reference.

Table 13 Final Sites for II Evaluation

Vista Carlsbad Interceptor			
	Site	Final Q	Net Q
U/S BVPS	V1	5.058	5.058
	5B-24	0.085	0.085
	1D-3	0.422	0.422
	BVPS	5.867	0.303
U/S Foxes	17D-3	0.610	0.610
	16D-12	1.118	0.508
U/S Agua Hedionda	9B-59	0.367	0.367
	21A-6*	7.469	0.117
U/S Cannon	22D-2	0.217	0.217
	23A-68	1.084	0.867
U/S C3	C3	9.523	0.970
Buena Vista Interceptor			
	Site	RevQ	RevNetQ
U/S B1	B2	2.328	2.328
	V2	0.416	0.416
	31A-12	0.061166	0.061166
	36B-34*	2.900	0.095
	B1	3.305	0.405
Vallecitos Interceptor			
U/S C1	VA1	5.075	5.075
	C1	6.211	1.136
Leucadia Interceptor			
U/S C2	47C-15	0.763	0.763
	L1	5.217	5.217
	C2	6.087	0.107

From 20090501 Consolidated_Q_Analysis ! NetFlowCalcsAdj

Defining the proper flow for the Average Dry Day is the foundation to a more complete understanding of the Inflow and Infiltration. The ADWF is used as the baseline to compare wet

weather excursions from dry weather conditions. The following sections discuss in more detail the process and findings for the wet weather analysis.

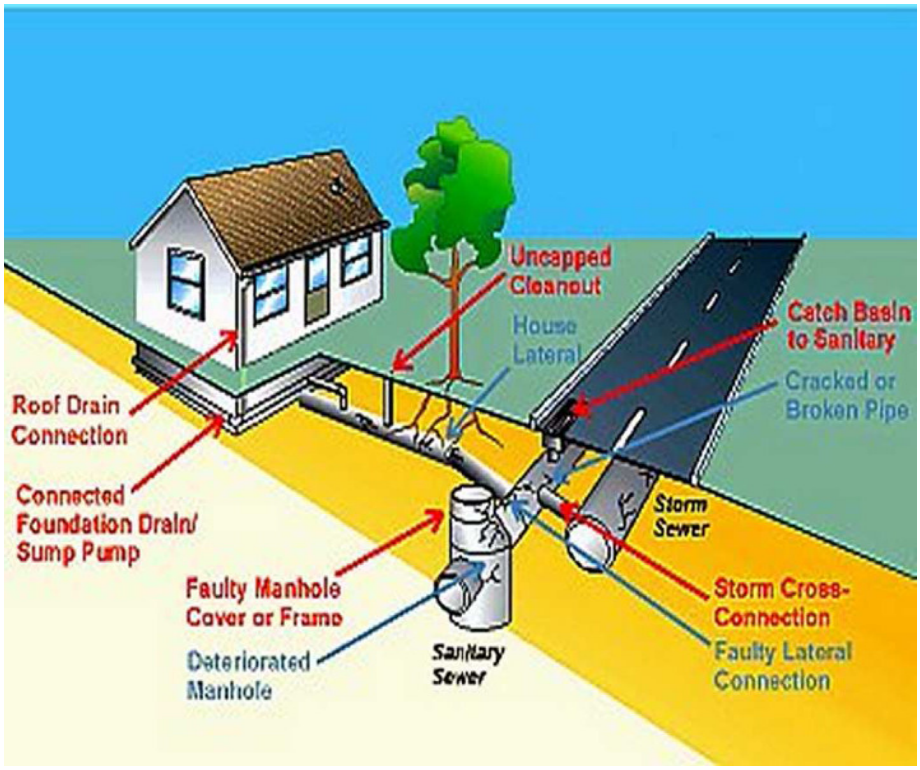
Note that the information provided in Table 13 Final Sites for II Evaluation is used for determining defect flow quantities, locations, type and prioritization. The calibration process in the hydraulic model is based on flow comparisons at the permanent flow measurement sites.

Inflow and Infiltration

Sanitary sewer systems are subject to the entry of rainfall and elevated groundwater through direct and indirect connections. These "defect flows" are further classified into inflow and infiltration or I/I. The following discussion describes the characteristics of each type and gives specific examples of each in the Carlsbad collection system.

Typical examples of defect locations in a system are shown in the following Figure 8.

Figure 8 Sources of Inflow and Infiltration

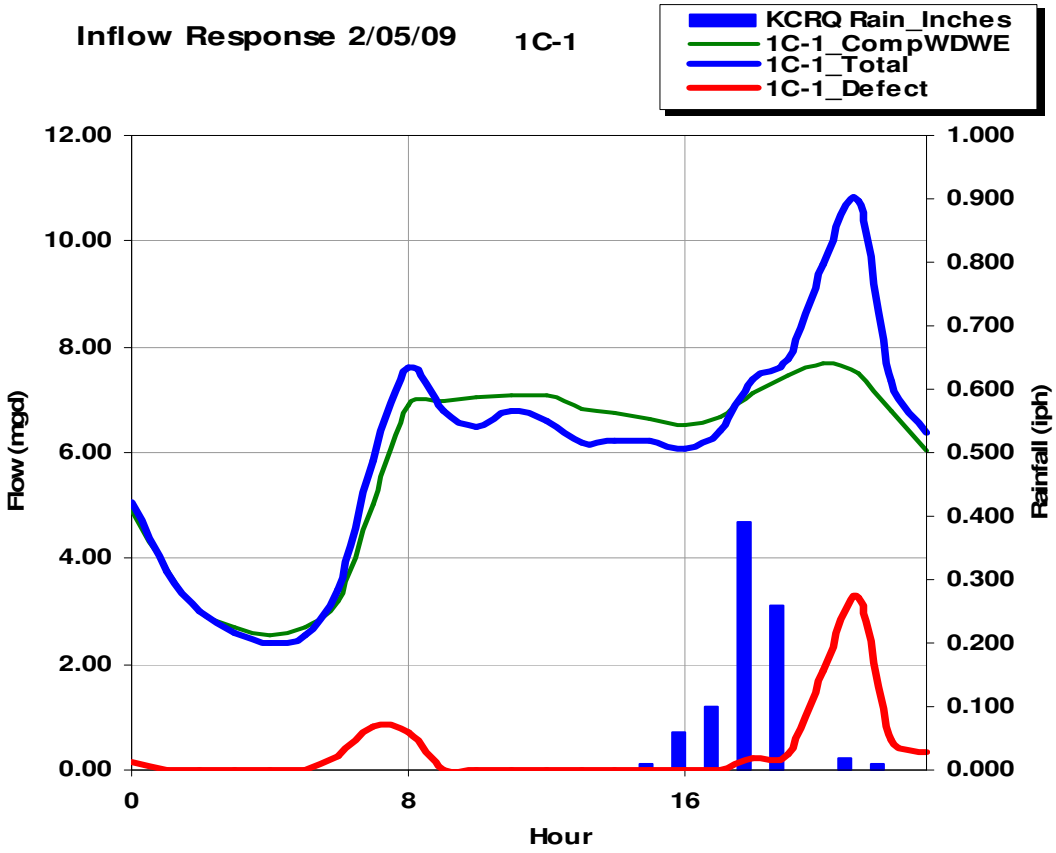


Inflow

Inflow is defect flow that comes from direct connections to the surface. This may be through cross connections to storm drains, roof drains, yard drains or through missing clean out covers, manhole covers or cracks that are directly connected to the surface. The primary characteristics of inflow are the rapid response to the onset and cessation of rainfall. A pure inflow defect would contribute flow immediately upon the beginning of the rainfall and stop

immediately when the rainfall stops. Due to differences in the location of the rain gauges, the flow measurement sites and the defects, delays of 1-2 hours are often observed. Inflow defects are relatively simple to locate and inexpensive to repair. Inflow defects create significant impacts on the hydraulic capacity of the system. For this reason the "extreme event" in the collection system is the wet weather event that occurs during the design event. The following Figure 9 shows the predominate inflow response that was observed at site IC-1 on February 5, 2009. This site was located in the mall parking lot near the permanent site at the Buena Vista Pump Station (BVPS) near Jefferson Street and Highway 78.

Figure 9 Inflow Response

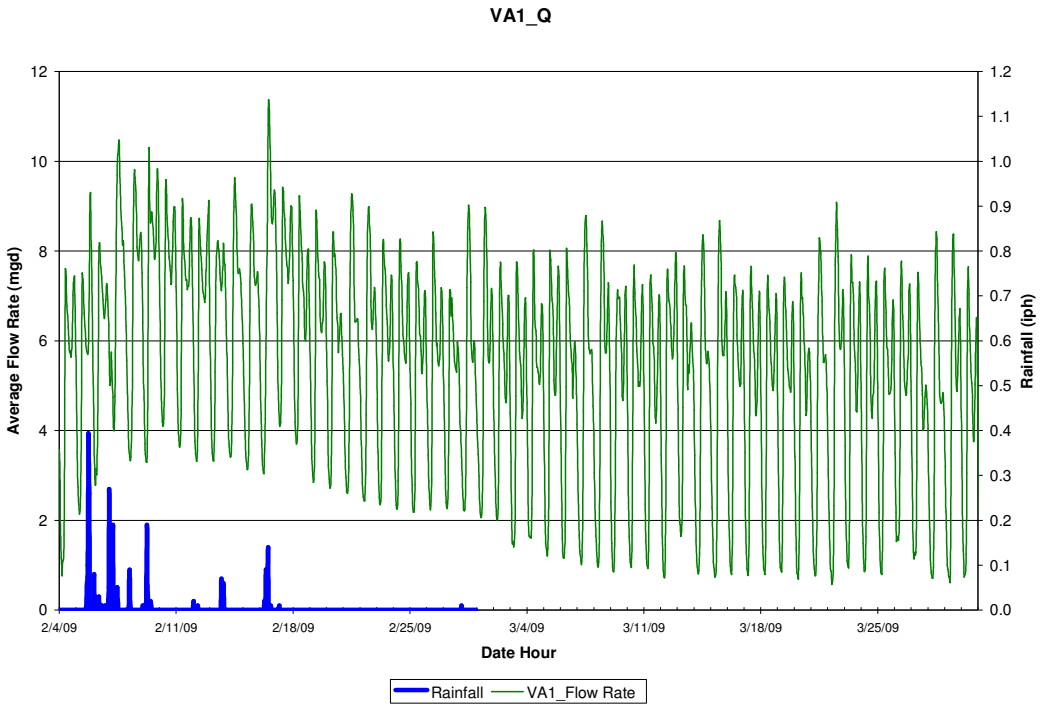


Infiltration

Infiltration is the component of defect flow that comes from indirect connections to the surface. Common infiltration sources include cracked pipe and manholes especially in areas that are subject to changes in groundwater elevations. Base infiltration occurs constantly regardless of the weather. Rainfall Induced Infiltration occurs only as a result of rainfall and is characterized by a long delay between the onset of rainfall and the increase in total flow. Similarly decreases to pre-rainfall levels may take several days, weeks or months depending on the groundwater levels and the severity and distribution of the cracks. While infiltration does not affect the peak rate in the collection system, it can have a deleterious effect on the system

due to increases in volume. These volume increases incur additional pumping and treatment costs. Infiltration is most readily identified by observing the change in minimum flow rates. The following Figure 10 shows the slow increase and delayed decrease in minimum flows observed at permanent site VA1. It takes almost three weeks to return to the minimum flows recorded before 2/4/2009. This indicates that the Vallecitos system is subject to widespread infiltration defects.

Figure 10 Infiltration Example VA1



Standardize

In each of the sub-basins or drainage areas there is a wide variation in the total area, upstream length of pipe and rainfall. To compare each site on an equal basis, the flows are normalized or standardized by dividing the defect flow by the length of upstream pipe and dividing by the total rainfall. This provides us with a defect flow rate or volume per foot of pipe and per inch of rainfall. Basin unit defect flows may then be used as the basis of determining which basin is the leakiest during the flow measurement period. Standardization is the method that is used to compare basins of varying sizes.

Defect Dominance

Defect dominance is the term used to describe which defect flow component, infiltration or inflow is prevalent in a given basin. While there are a variety of methods used to establish dominance the one used in this study was to compare the 24 hour and 72 hour defect flows. The underlying premise here is that the 24 hour increase in flows represents inflow dominated

defects while the 72 hour increase in flows is an indication of the infiltration defects. In all sites within Carlsbad, inflow defects were dominant. No sites were observed to have an infiltration defect type as the dominant component.

Analysis Products

All analyses are supported by tables and graphics that show the calculations that were performed using the available temporary flow metering data. Each site has a table and supporting graphics in the Appendix. An example of the flow measurement graphics for the wet weather events and the regression curves are shown in the following figures.

The regression analysis compares the increase in wastewater volume to rainfall volume and the increase in wastewater flow rate to rainfall intensity. This process yields two formulas that may be used to predict defect volume or rate at a design event. Since the regression analysis is performed on only three rainfall events in 2009, in the modeling process, the maximum of observed or predicted defect flow increases will be used.

Figure 11 Wet Weather Analysis

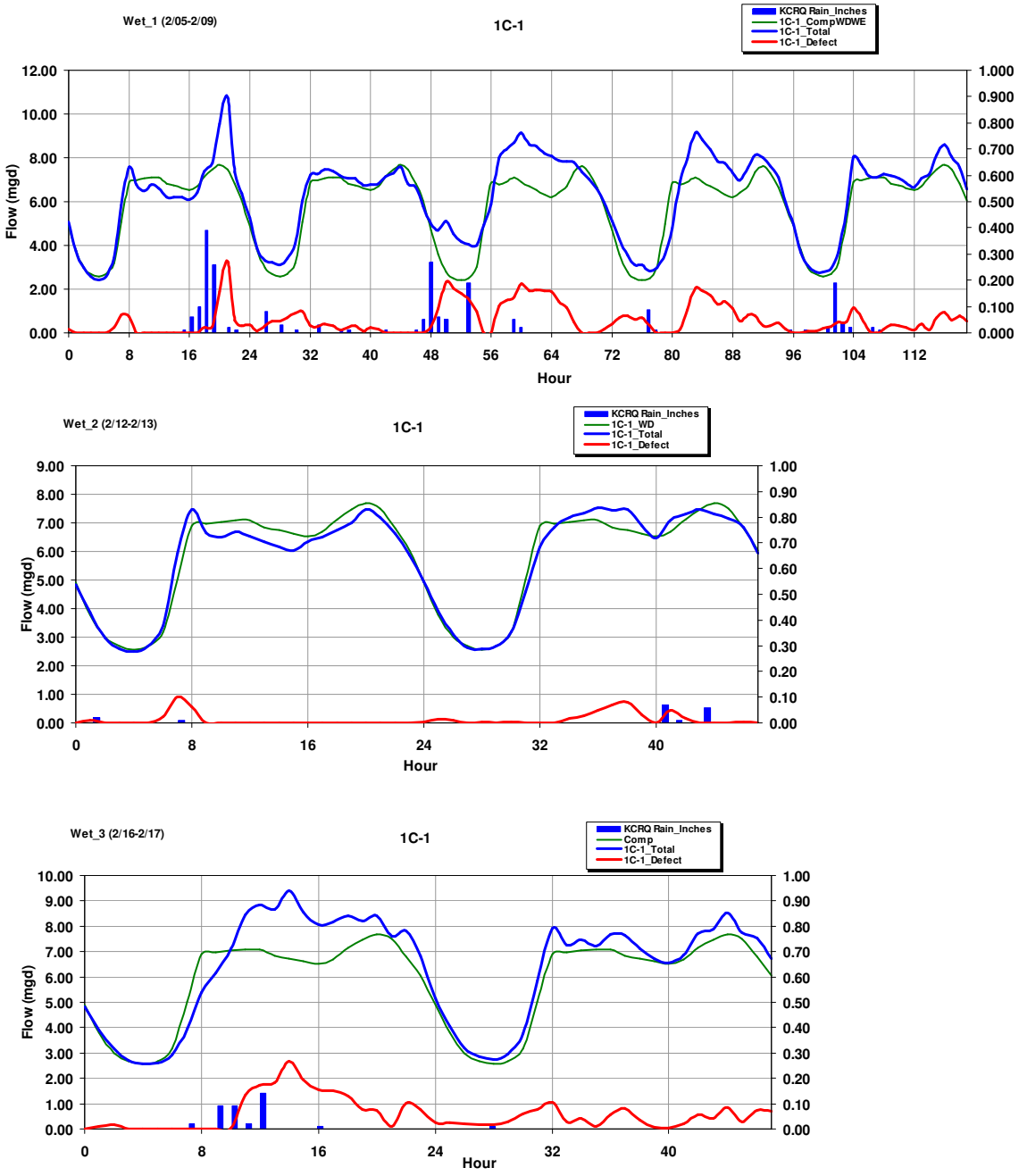
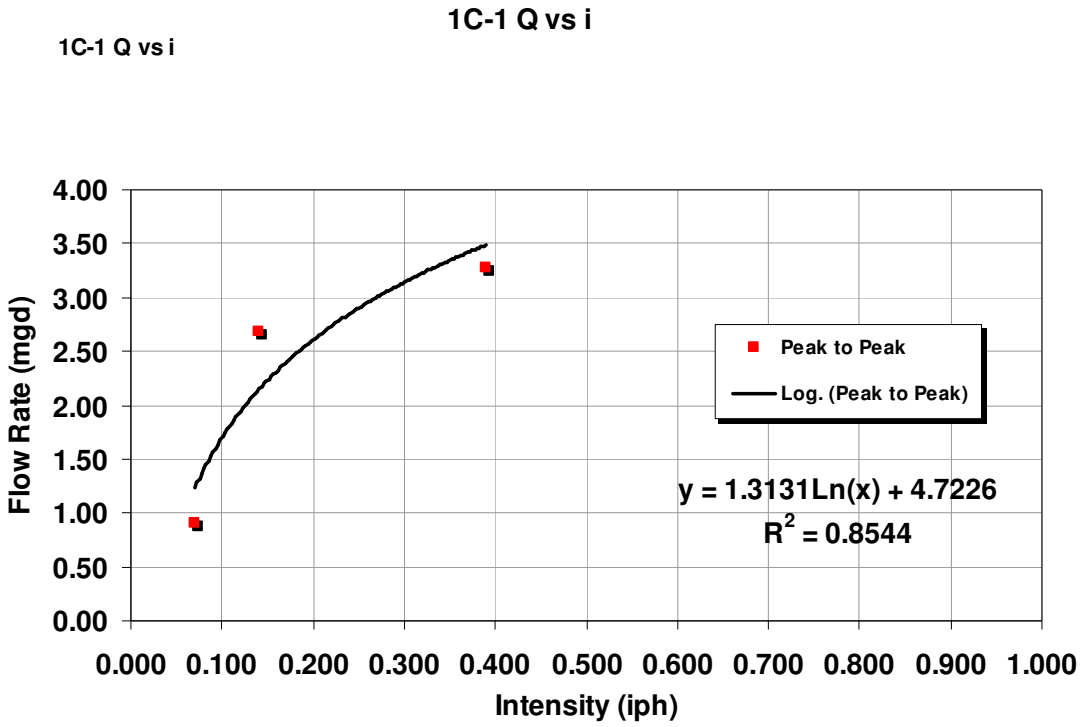


Figure 12 Defect Flow Rainfall Regression Analysis



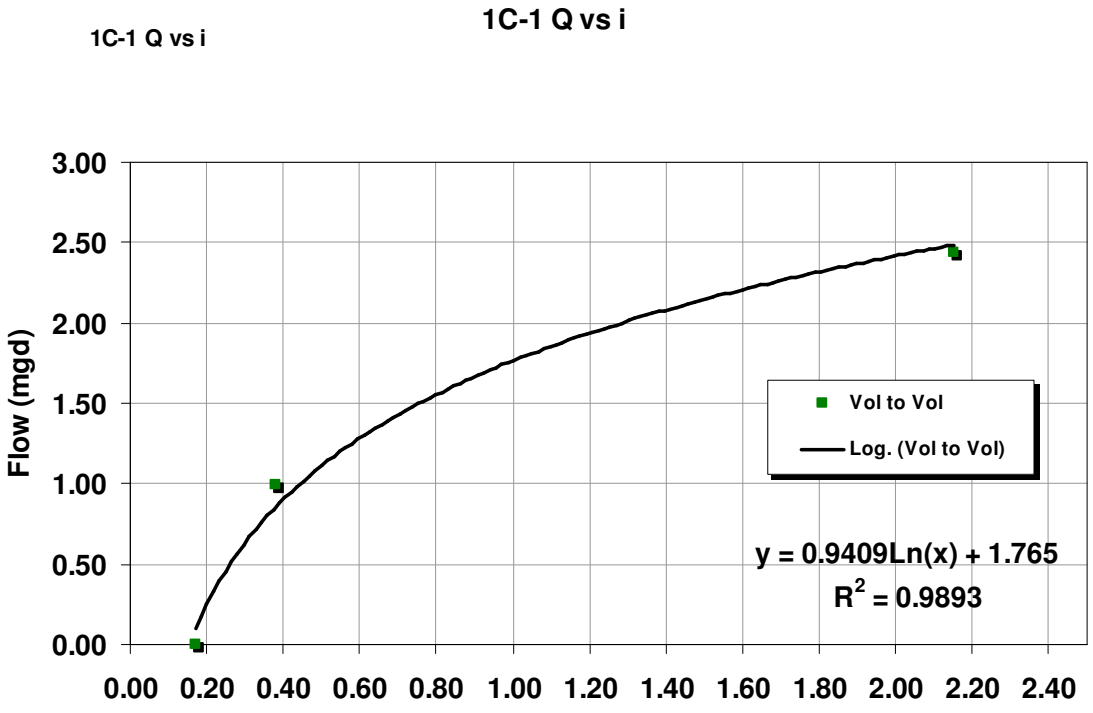


Table 14 Wet Weather Analysis Table (Truncated)

1C-1	1C-1	1C-1	1C-1	1C-1	KCRQ	1C-1	1C-1	1C-1	KCRQ	1C-1	1C-1	1C-1	
ADWF	ADWF	Wet_1 (2/05-2/09)				Wet_2 (2/12-2/13)				Wet_3 (2/16-2/17)			
WD	WE	CompWDW	Total	Defect	Rain_Inches	WD	Total	Defect	Rain_Inches	Comp	Total	Defect	Rain_Inche
1C-1_WD	1C-1_WE	_CompWD	1C-1_Total	C-1_Defec	KCRQ Rain_In	1C-1_WD	1C-1_Tota	1C-1_Defe	KCRQ Rai	1C-1_Com	1C-1_Tota	1C-1_Defe	KCRQ Rai
4.908	4.689	4.908	5.058	0.150	0.000	4.908	4.832	0.000	0.00	4.908	4.818	0.000	0.00
3.796	3.612	3.796	3.743	0.000	0.000	3.796	3.878	0.082	0.02	3.796	3.903	0.107	0.00
2.987	2.775	2.987	2.991	0.004	0.000	2.987	2.962	0.000	0.00	2.987	3.178	0.191	0.00
2.693	2.481	2.693	2.572	0.000	0.000	2.693	2.581	0.000	0.00	2.693	2.707	0.015	0.00
2.556	2.393	2.556	2.409	0.000	0.000	2.556	2.514	0.000	0.00	2.556	2.567	0.011	0.00
2.683	2.491	2.683	2.554	0.000	0.000	2.683	2.677	0.000	0.00	2.683	2.617	0.000	0.00
3.174	3.019	3.174	3.418	0.244	0.000	3.174	3.397	0.223	0.00	3.174	2.916	0.000	0.00
5.042	4.967	5.042	5.851	0.809	0.000	5.042	5.952	0.910	0.01	5.042	3.929	0.000	0.02
6.893	6.849	6.893	7.609	0.716	0.000	6.893	7.465	0.573	0.00	6.893	5.372	0.000	0.00
6.975	6.776	6.975	6.789	0.000	0.000	6.975	6.644	0.000	0.00	6.975	6.163	0.000	0.09
7.045	6.894	7.045	6.475	0.000	0.000	7.045	6.491	0.000	0.00	7.045	7.097	0.052	0.09
7.091	7.092	7.091	6.786	0.000	0.000	7.091	6.691	0.000	0.00	7.091	8.439	1.348	0.02
7.090	6.888	7.090	6.609	0.000	0.000	7.090	6.533	0.000	0.00	7.090	8.833	1.743	0.14
6.830	6.684	6.830	6.205	0.000	0.000	6.830	6.354	0.000	0.00	6.830	8.659	1.829	0.00
6.738	6.538	6.738	6.218	0.000	0.000	6.738	6.142	0.000	0.00	6.738	9.417	2.679	0.00
6.630	6.315	6.630	6.216	0.000	0.010	6.630	6.028	0.000	0.00	6.630	8.557	1.927	0.00
6.528	6.204	6.528	6.063	0.000	0.060	6.528	6.349	0.000	0.00	6.528	8.063	1.535	0.01
6.674	6.428	6.674	6.404	0.000	0.100	6.674	6.511	0.000	0.00	6.674	8.172	1.497	0.00
7.140	6.699	7.140	7.383	0.243	0.390	7.140	6.764	0.000	0.00	7.140	8.426	1.286	0.00
7.461	7.341	7.461	7.755	0.294	0.260	7.461	6.998	0.000	0.00	7.461	8.220	0.759	0.00
7.679	7.648	7.679	9.550	1.870	0.000	7.679	7.472	0.000	0.00	7.679	8.425	0.746	0.00
7.487	7.321	7.487	10.756	3.269	0.020	7.487	7.184	0.000	0.00	7.487	7.603	0.116	0.00
6.798	6.666	6.798	7.351	0.553	0.010	6.798	6.622	0.000	0.00	6.798	7.806	1.008	0.00
6.042	5.785	6.042	6.387	0.345	0.000	6.042	5.886	0.000	0.00	6.042	6.823	0.781	0.00
		4.908	5.257	0.349	0.000	4.908	4.926	0.019	0.00	4.908	5.156	0.248	0.00
		3.796	3.888	0.092	0.000	3.796	3.915	0.118	0.00	3.796	4.036	0.240	0.00
		2.987	3.308	0.321	0.080	2.987	3.092	0.105	0.00	2.987	3.210	0.223	0.00
		2.693	3.221	0.528	0.000	2.693	2.633	0.000	0.00	2.693	2.852	0.159	0.00
		2.556	3.084	0.527	0.030	2.556	2.585	0.029	0.00	2.556	2.729	0.173	0.01
		2.683	3.374	0.692	0.000	2.683	2.697	0.014	0.00	2.683	2.974	0.292	0.00
		3.174	4.087	0.913	0.010	3.174	3.198	0.024	0.00	3.174	3.761	0.587	0.00
		5.042	6.022	0.979	0.000	5.042	4.595	0.000	0.00	5.042	5.831	0.789	0.00
		6.893	7.227	0.335	0.000	6.893	6.151	0.000	0.00	6.893	7.937	1.044	0.00
		6.975	7.276	0.301	0.030	6.975	6.839	0.000	0.00	6.975	7.267	0.293	0.00
		7.045	7.463	0.418	0.000	7.045	7.196	0.151	0.00	7.045	7.457	0.412	0.00
		7.091	7.400	0.309	0.000	7.091	7.351	0.260	0.00	7.091	7.210	0.119	0.00
		7.090	7.204	0.114	0.010	7.090	7.540	0.451	0.00	7.090	7.669	0.579	0.00
		6.830	7.080	0.250	0.010	6.830	7.446	0.617	0.00	6.830	7.654	0.824	0.00
		6.738	7.067	0.328	0.000	6.738	7.464	0.726	0.00	6.738	7.098	0.360	0.00
		6.630	6.720	0.089	0.000	6.630	6.900	0.270	0.00	6.630	6.712	0.082	0.00
		6.528	6.758	0.230	0.000	6.528	6.468	0.000	0.00	6.528	6.560	0.032	0.00
		6.674	6.818	0.143	0.000	6.674	7.098	0.423	0.07	6.674	6.878	0.203	0.00
		7.140	7.148	0.009	0.010	7.140	7.299	0.160	0.01	7.140	7.697	0.557	0.00
		7.461	7.302	0.000	0.000	7.461	7.469	0.008	0.00	7.461	7.887	0.426	0.00
		7.679	7.601	0.000	0.000	7.679	7.305	0.000	0.06	7.679	8.514	0.835	0.00
		7.487	6.804	0.000	0.000	7.487	7.155	0.000	0.00	7.487	7.752	0.266	0.00
		6.798	6.643	0.000	0.010	6.798	6.840	0.042	0.00	6.798	7.529	0.731	0.00
		6.042	5.807	0.000	0.050	6.042	5.934	0.000	0.00	6.042	6.742	0.700	0.00
5.789	5.606	4.689	4.960	0.271	0.270								
		3.612	4.712	1.100	0.060								
		6.798	7.562	0.764	0.00								
		6.042	6.569	0.527	0.00								
		28.580	31.020	2.440	2.15	11.578	11.459	0.000	0.170	11.578	12.576	0.998	0.380
		Event 1	Inc Volume	2.440	2.15	Event_2	Inc Volume	0.000	0.170	Event_3	Inc Volume	0.998	0.380
		1C-1	Max Rate	3.269	0.39	1C-1	Max Rate	0.910	0.070	1C-1	Max Rate	2.679	0.140

Results

Table 15 indicates the relative ranking of defect flows observed during the measurement period.

Table 15 Top 5 Net Unit Defect Flows

Net Unit Defect Flow		Defect Flow Volumes	
Rank	Site ID	Inflow-24hr. (gal/foot/in.)	Infil-72hr. (gal/foot/in.)
1	1C-1*	20.51	46.66
2	36B-34	8.31	16.49
3	B1	4.40	4.88
4	C-3*	2.04	10.68
5	22D-2	1.80	2.50
* Downstream locations - High 72hr. response			

The highest ranked inflow and infiltration response was observed on the Vista/Carlsbad Interceptor between the permanent site BVPS, the nearly equivalent temporary site 1C-1 and the upstream permanent site at V-1. This indicates that significant inflow and infiltration is entering the collection system along the Highway 78 corridor between the Vista V-1 Meter and the pump station at Jefferson Street. The flows in this area are more than twice as high as the next lowest observed flow.

The second and third highest observed flows occurred along the Buena/Vista Interceptor at temporary site 36B-4 and permanent site B-1. A common characteristic of the top three highest rankings is that they are low and in close proximity to creeks.

The fourth highest observed flows occurred at permanent site C-3. This site measured flows tributary to the lower reaches of the Vista/Carlsbad Interceptor.

The fifth highest observed flows occurred at temporary site 22D-2 which is also located in close proximity to a major water body.

Findings

1. Sufficient flow measurement information was available to characterize the Average Dry Weather Flow
2. Sufficient rainfall occurred during the flow measurement period to allow analysis of the systems response to rainfall.
3. Sufficient wet weather responses were analyzed to quantify the wet weather impact on the collection system.
4. Each area that flows to a particular flow meter (sub-basin) was ranked according to its observed unit defect flow.
5. While both inflow and infiltration responses were observed during the flow measurement period, inflow responses were dominant.
6. Considering the entire Carlsbad collection system, inflow and infiltration (I/I) observed during the flow measurement period is rated non-excessive by EPA Standards (1985).

7. Specific areas of the collection system require additional physical inspection and condition assessment to reduce their contributions to inflow and infiltration.

Recommendations

To further reduce inflow and infiltration in the highest ranked areas, additional physical inspection using CCTV, dye tracing, smoke testing and flow measurements should be performed. This would include the sub-basins along the Vista Carlsbad Interceptor and the Buena Vista Interceptor. The following Table 16 lists the observed defect flow rates for the top five basins with the highest unit defect flow. The table is ordered from most severe defect flow to least severe.

Table 16 Top 5 Net Unit Defect Flows

Net Unit Defect Flow		Defect Flow Volumes	
Rank	Site ID	Inflow-24hr. (gal/foot/in.)	Infil-72hr. (gal/foot/in.)
1	1C-1*	20.51	46.66
2	36B-34	8.31	16.49
3	B1	4.40	4.88
4	C-3*	2.04	10.68
5	22D-2	1.80	2.50
* Downstream locations - High 72hr. response			

Current CCTV operations should be modified to address the areas of highest concern first. Current CCTV inspections should be augmented with dye tracing to identify potential cross connections with the storm sewers and to positively identify and document roof drain and lateral connections with high inflow potential.

Figure 2 indicates graphically where the highest priority areas are located.

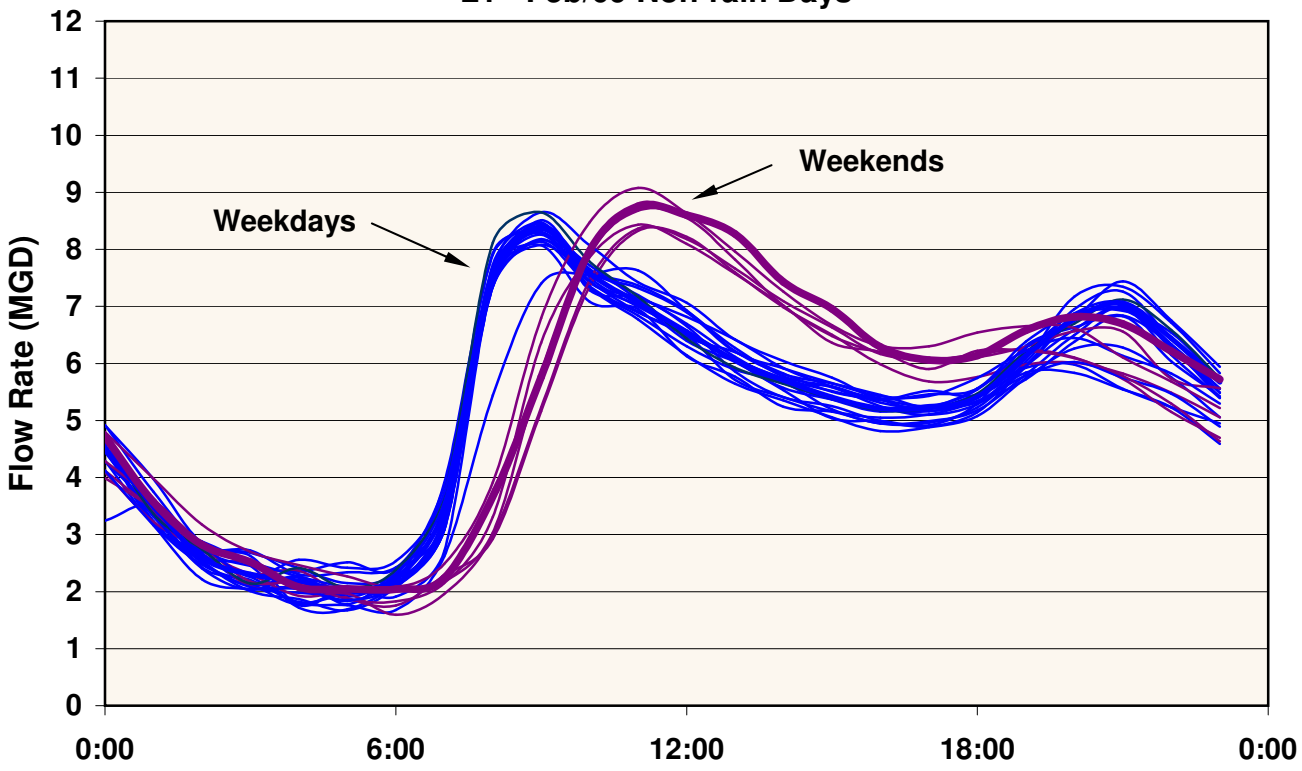
APPENDIX C
FLOW DATA

- February 2009 daily ADWF graphs and rain day graphs
- February 23, 2005 graphs and I&I flows
- Model verification flow charts

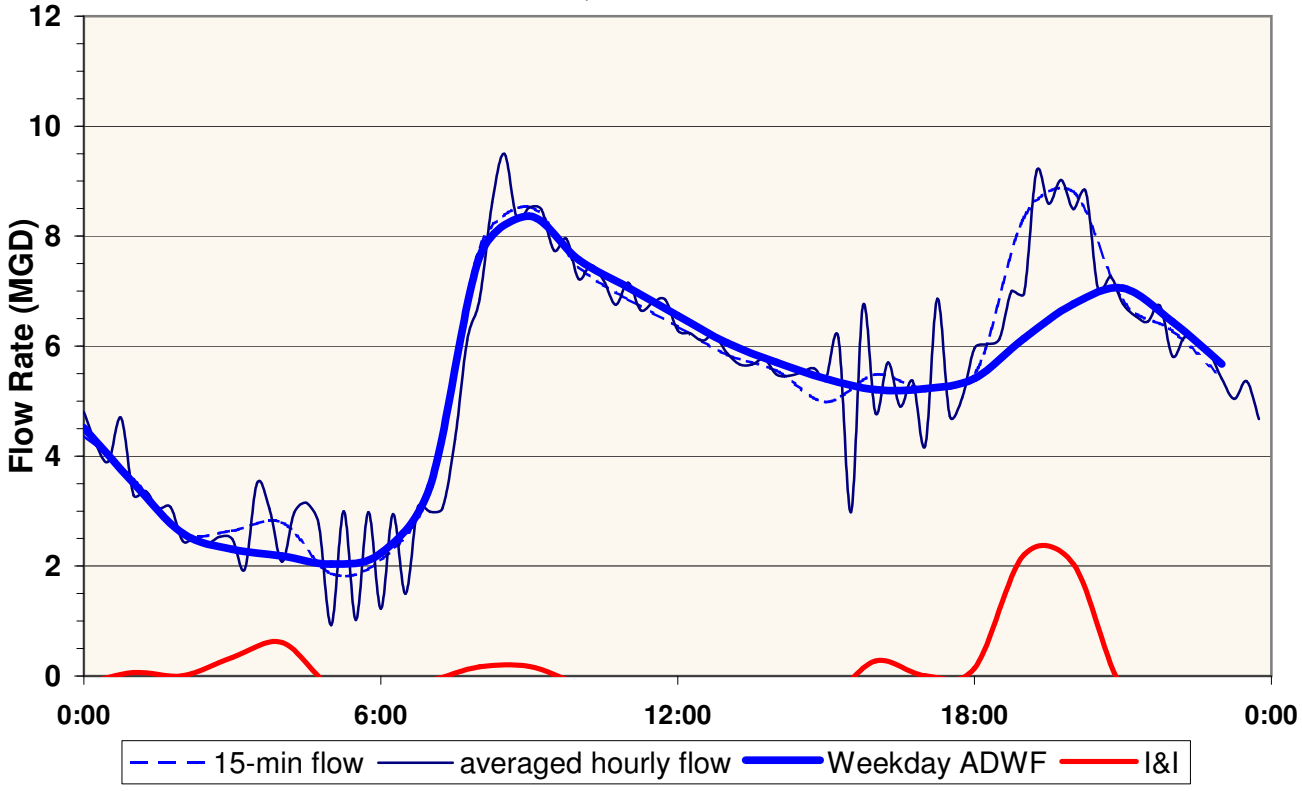
February 2009 Daily ADWF Graphs and Rain Day Graphs

Encina Flow Meter Data

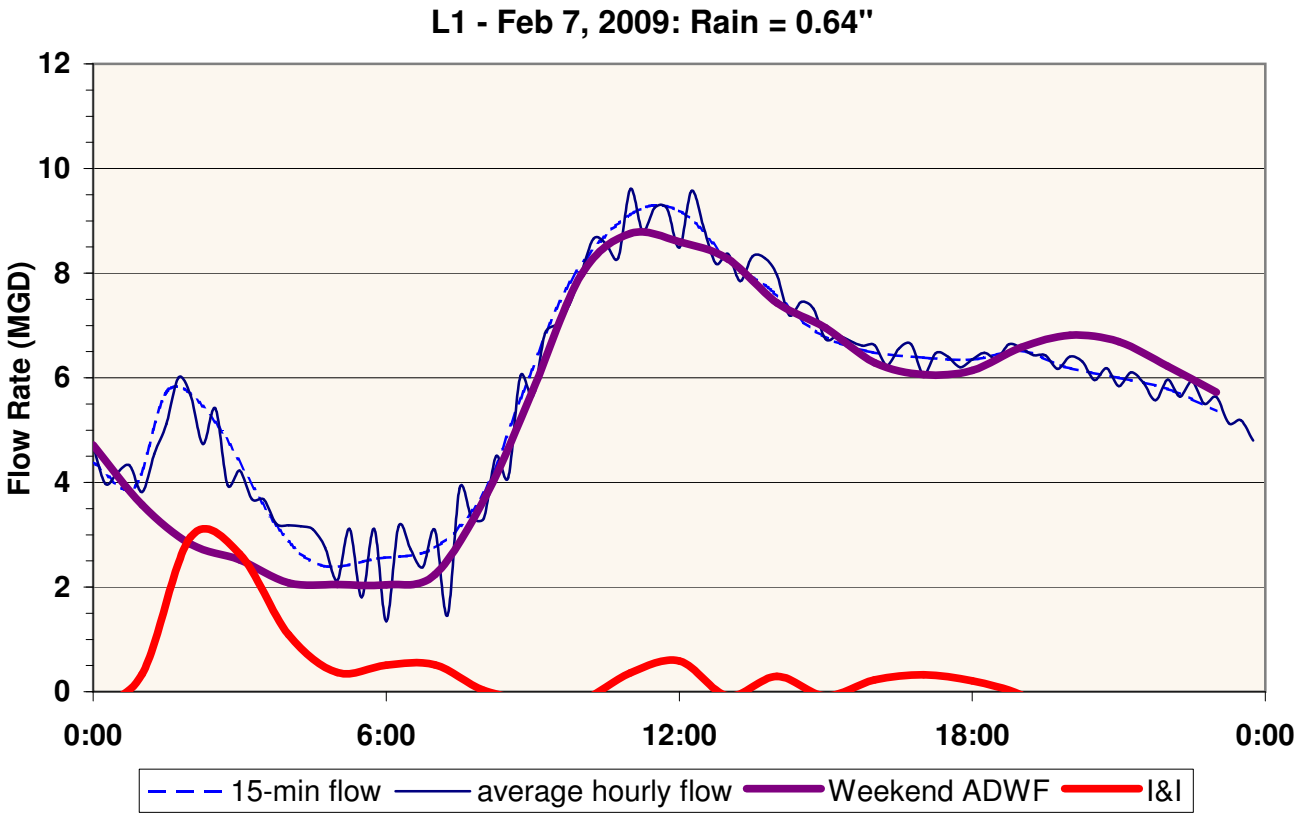
L1 - Feb/09 Non-rain Days

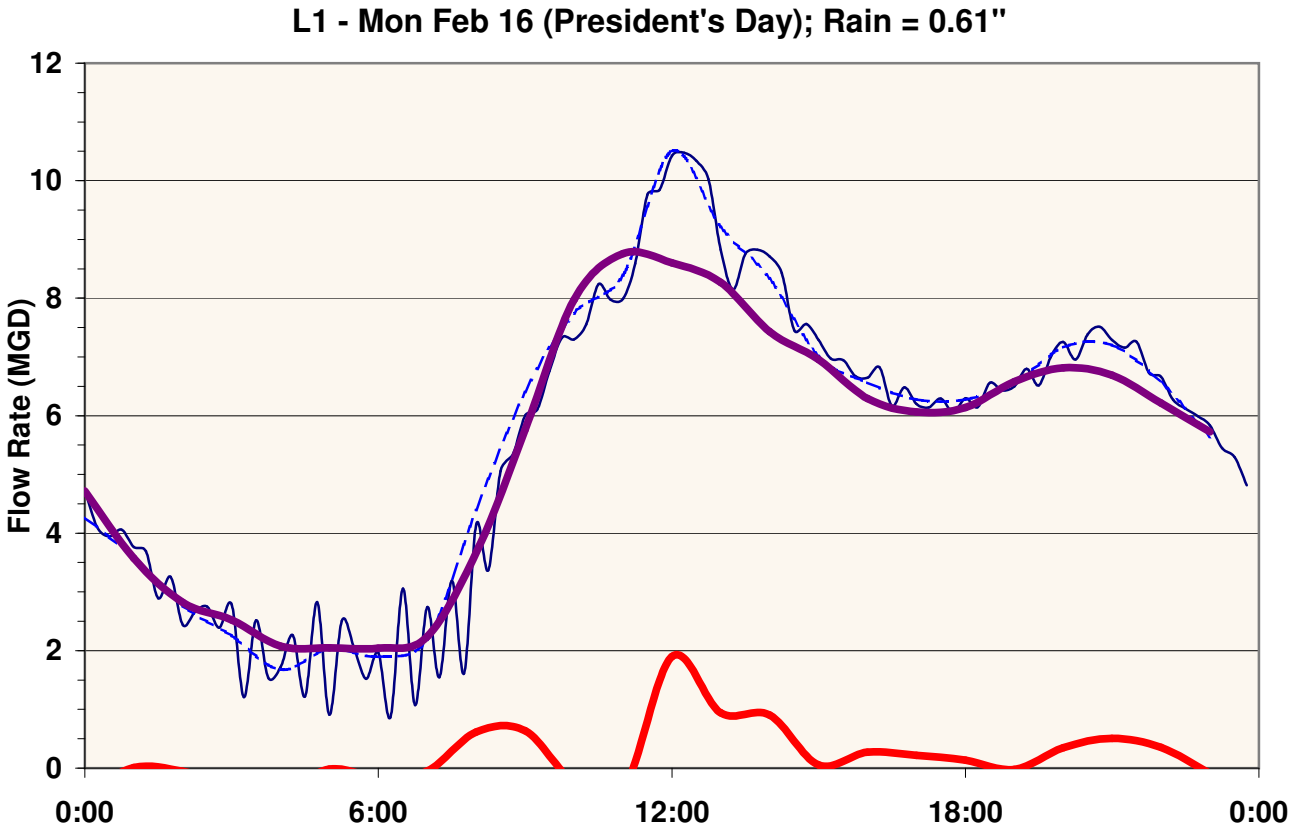


L1 - FEB 5, 2009: Rain = 0.85"



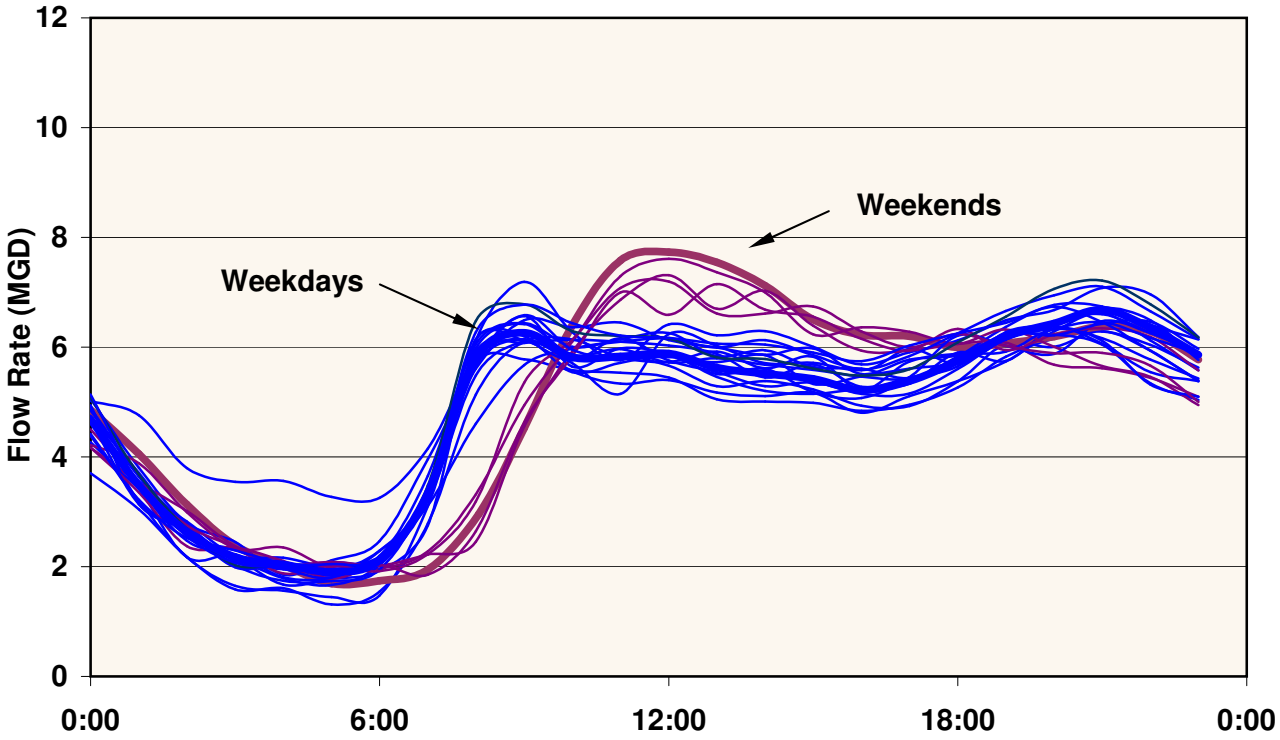
Encina Flow Meter Data



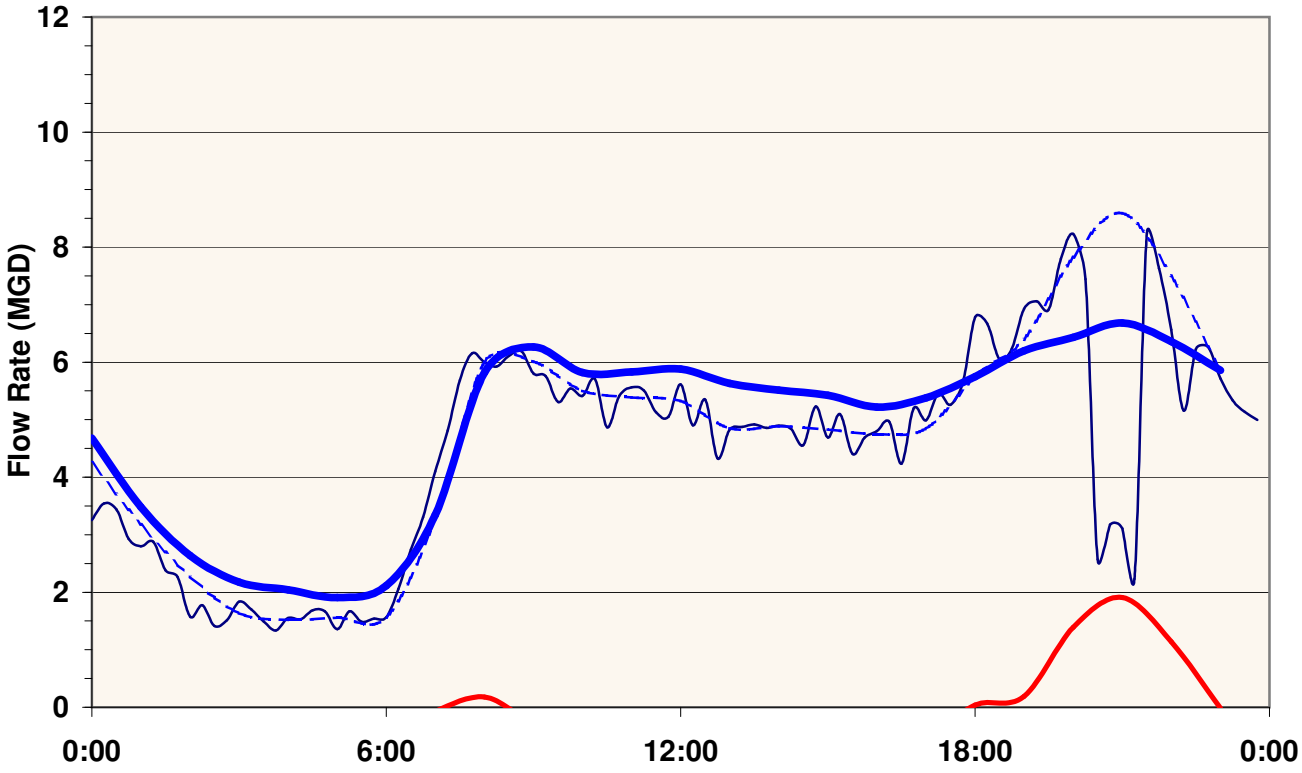


Encina Flow Meter Data

V1- Feb/09 Non-rain Days

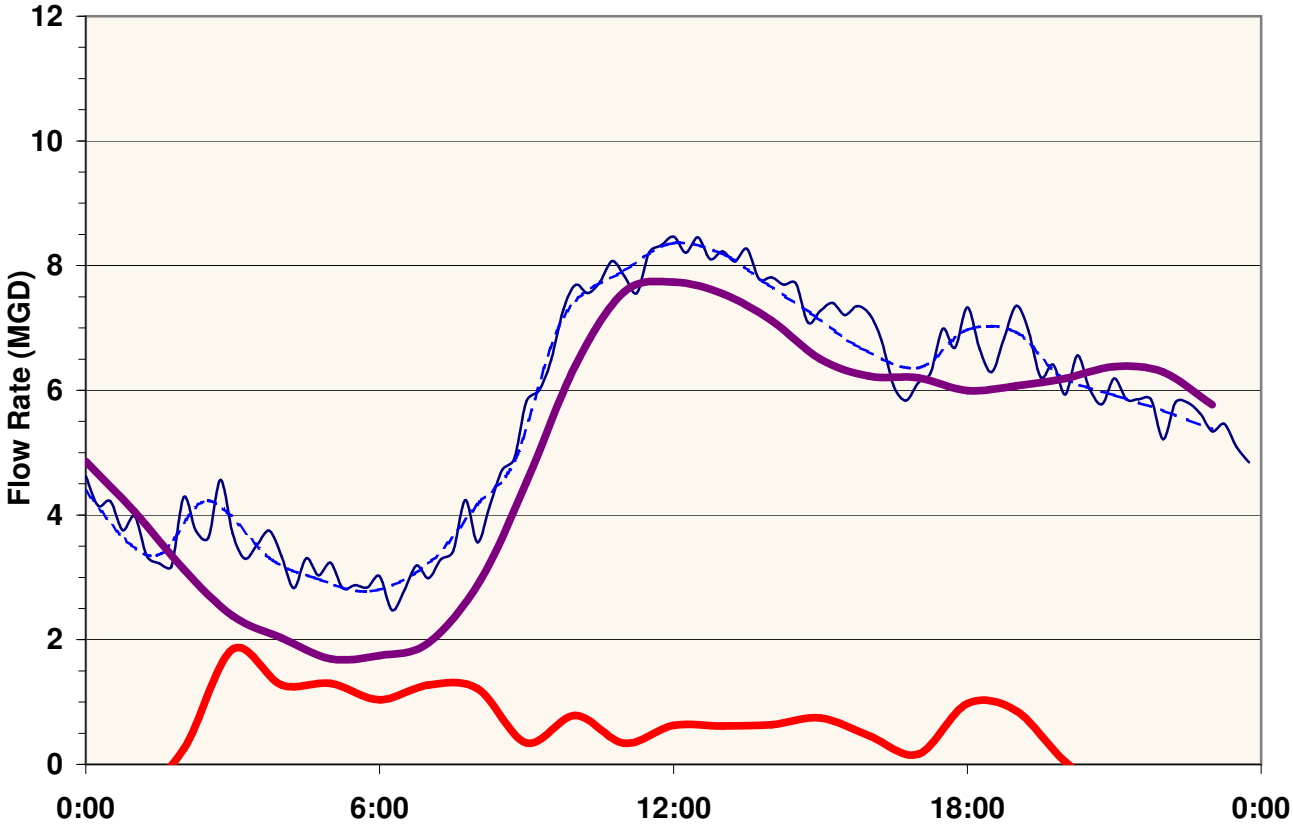


V1 - Thurs, Feb 5 - Rain

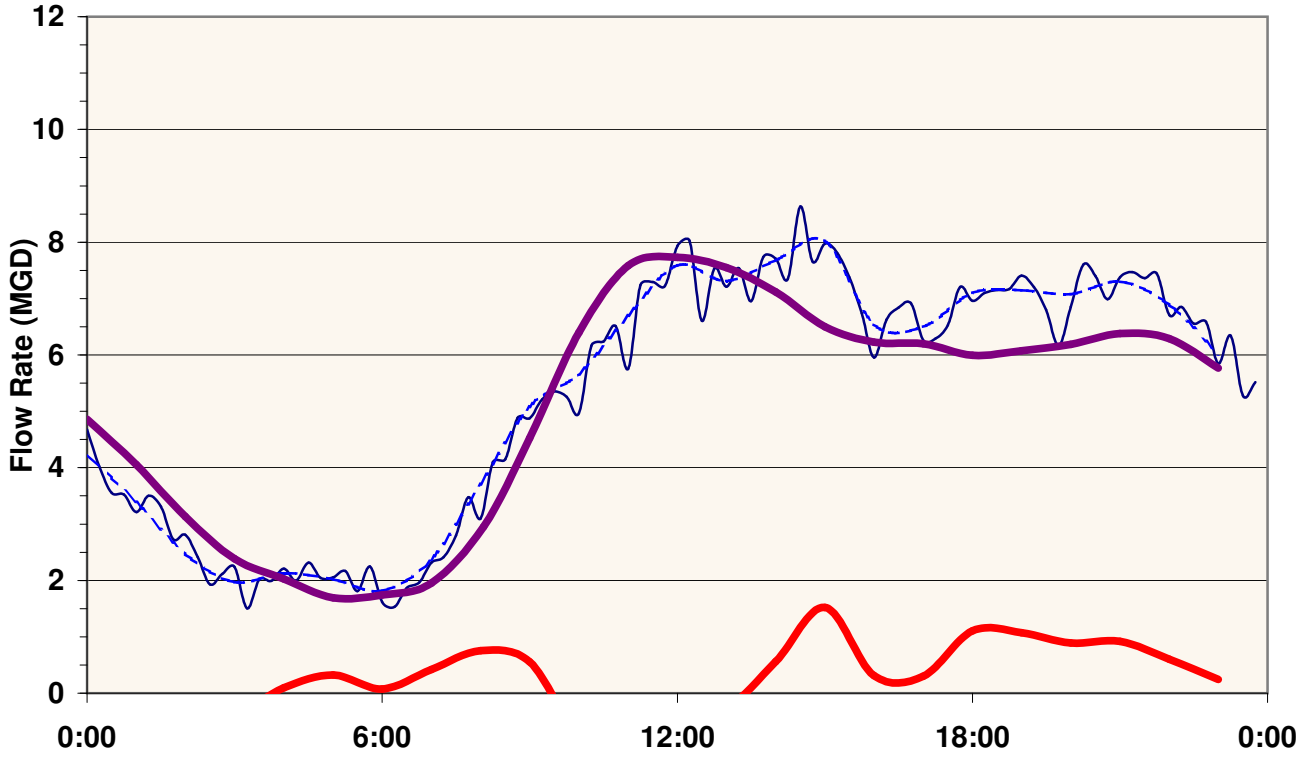


Encina Flow Meter Data

V1 - FEB 7 Rain

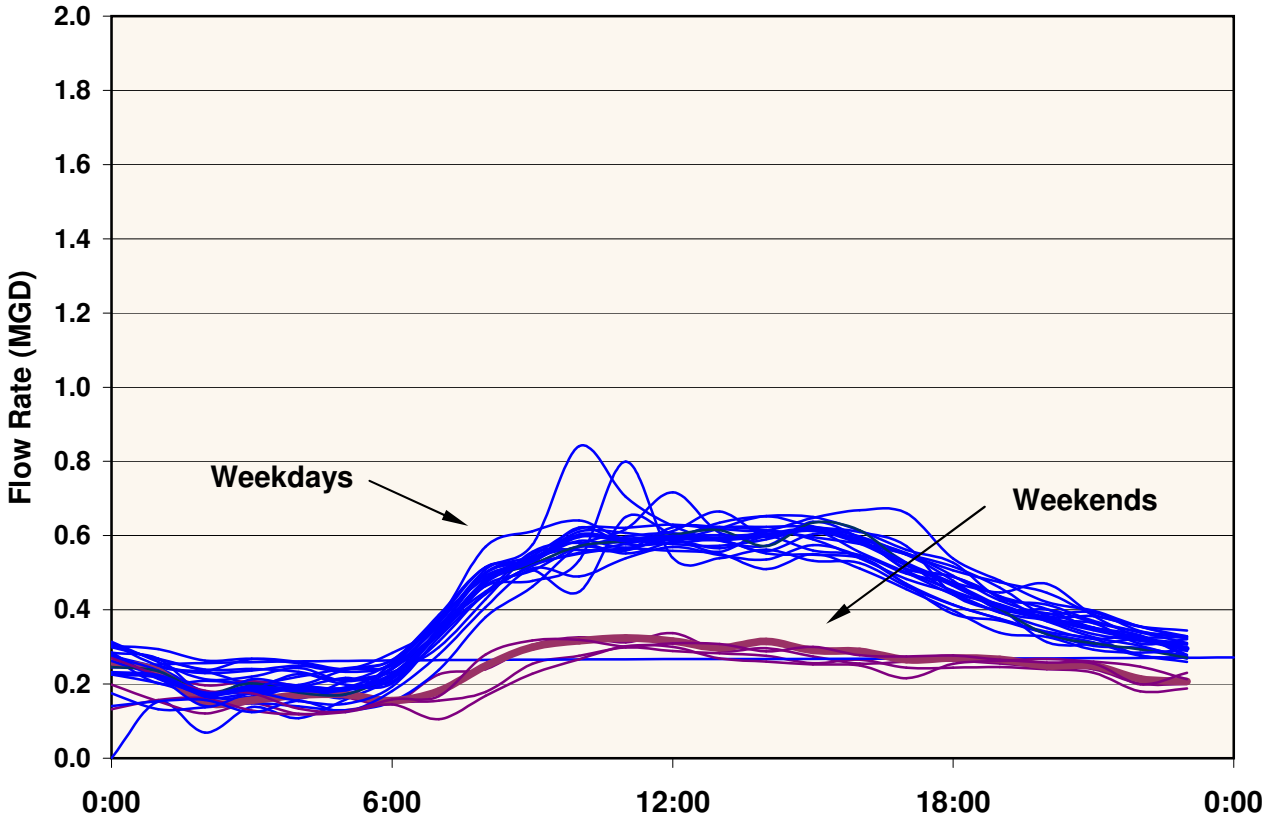


V1 - Mon Feb 16 (President's Day); Rain = 0.4"

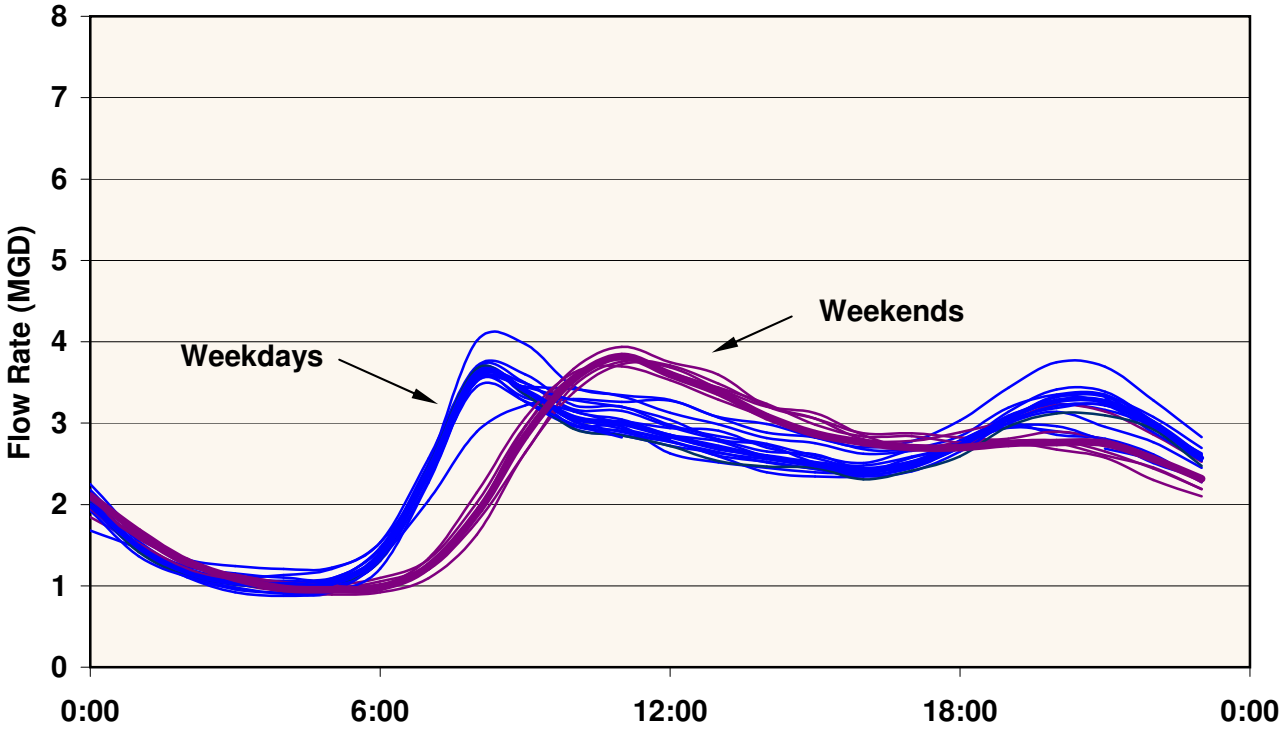


Encina Flow Meter Data

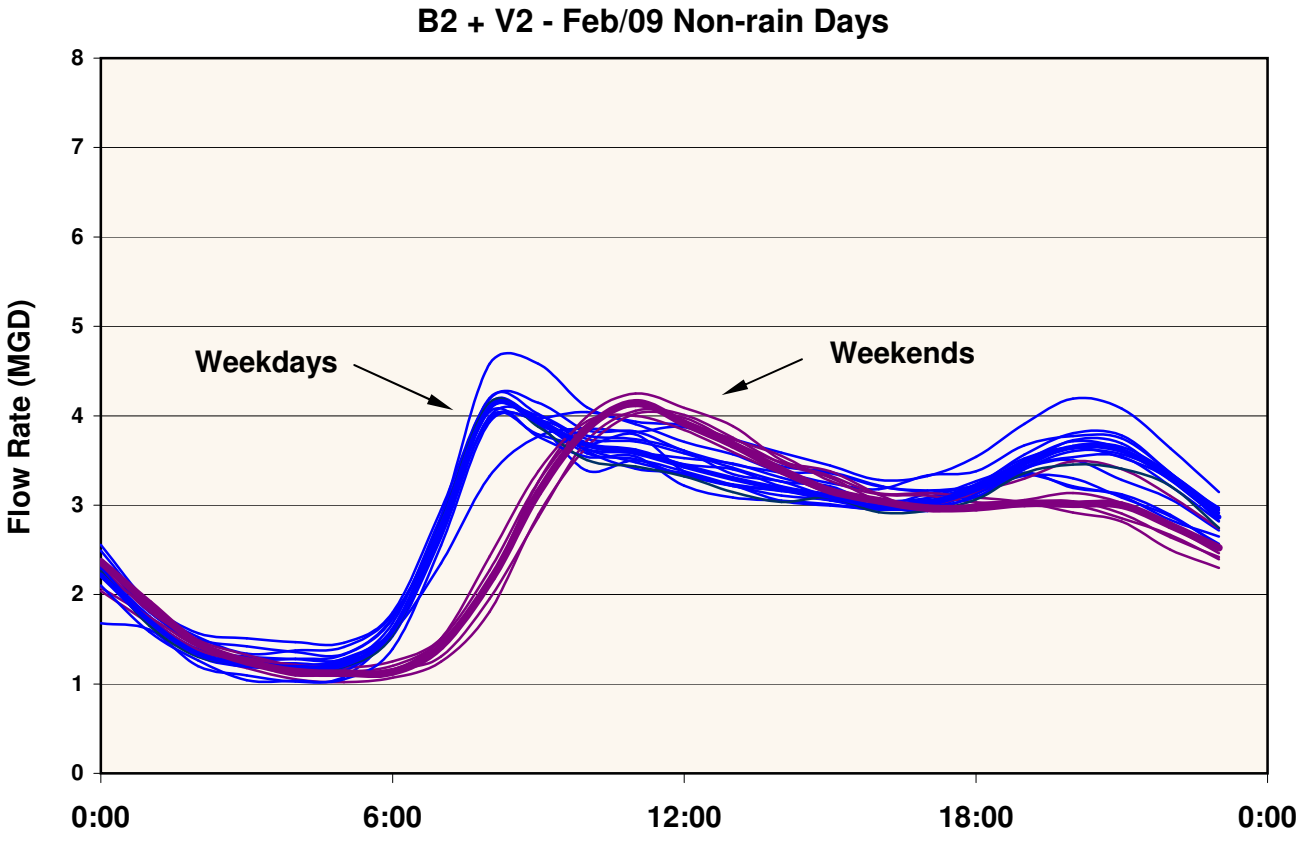
V2 - Feb/09 Non-rain Days

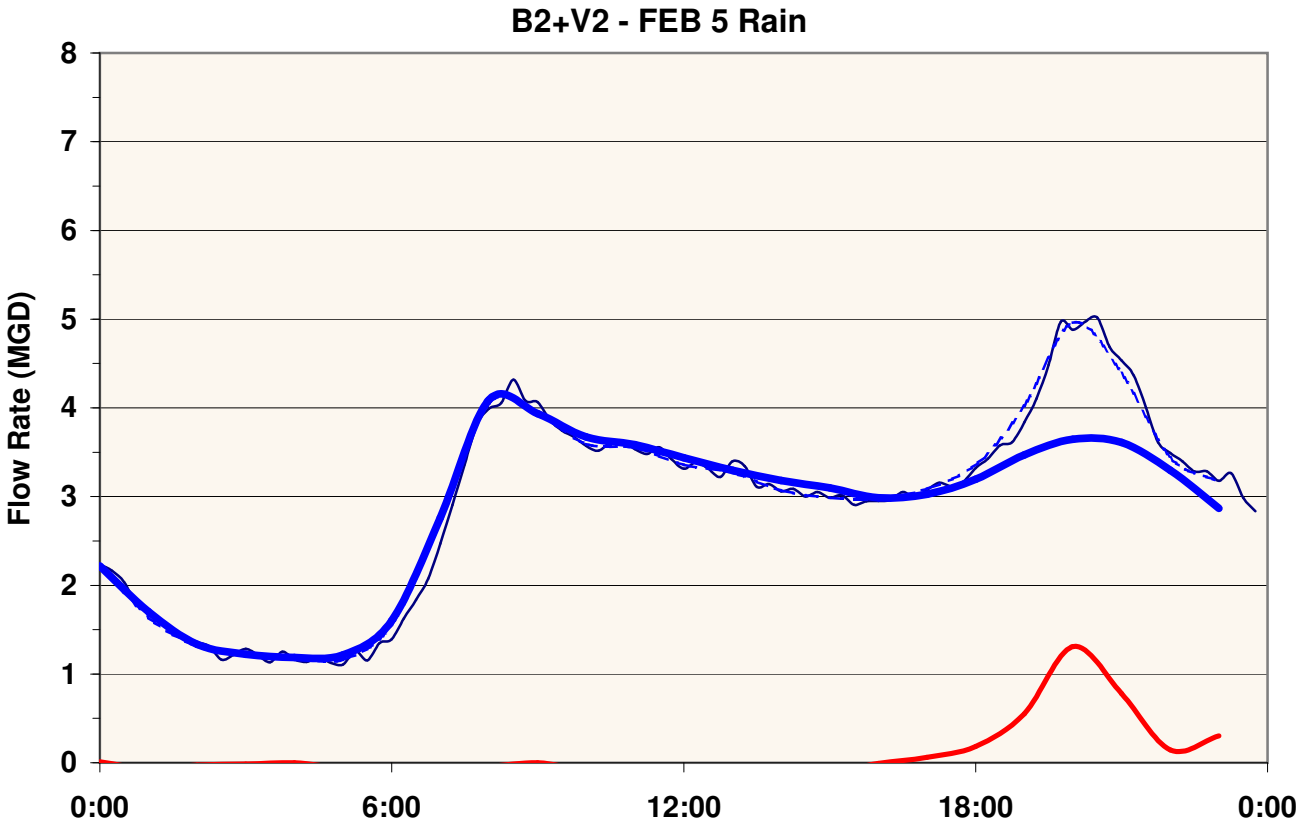


B2 - Feb/09 Non-rain Days



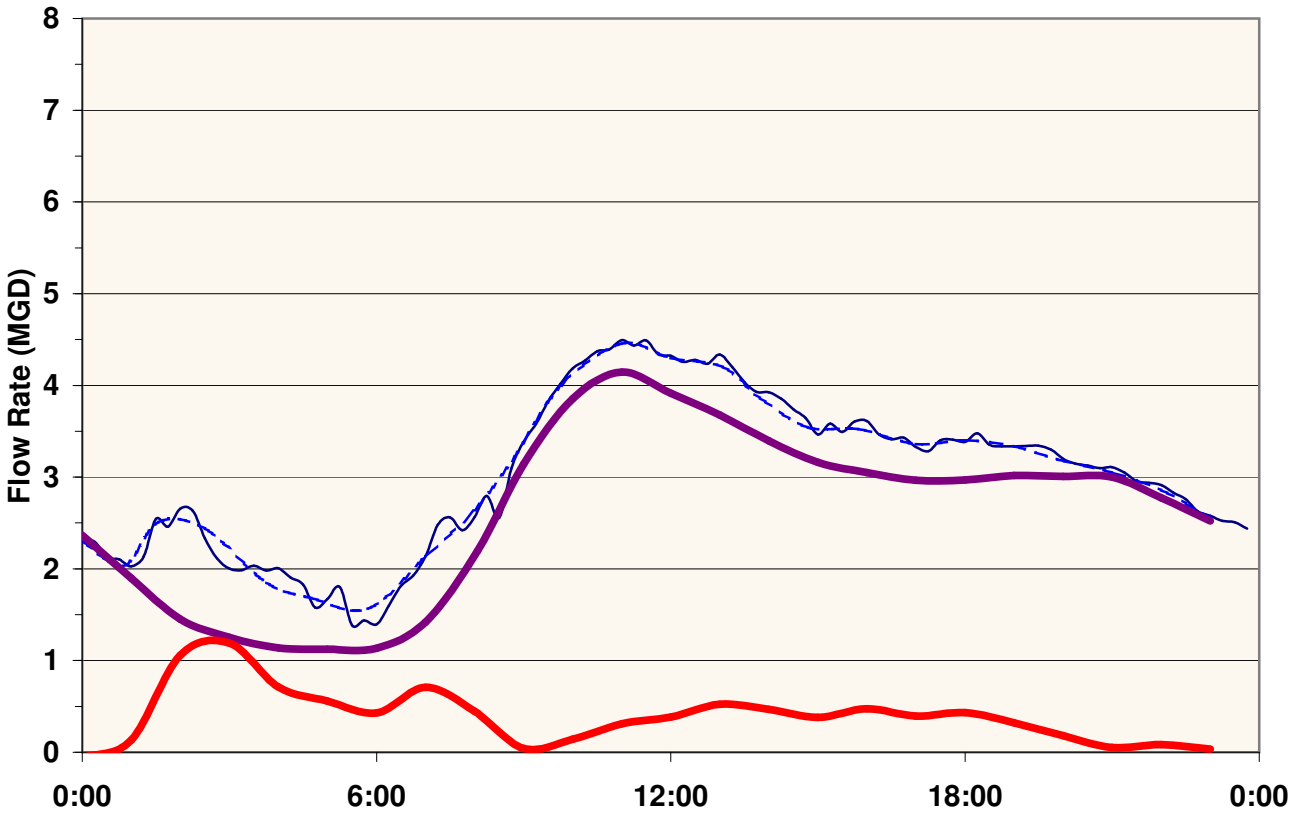
Encina Flow Meter Data



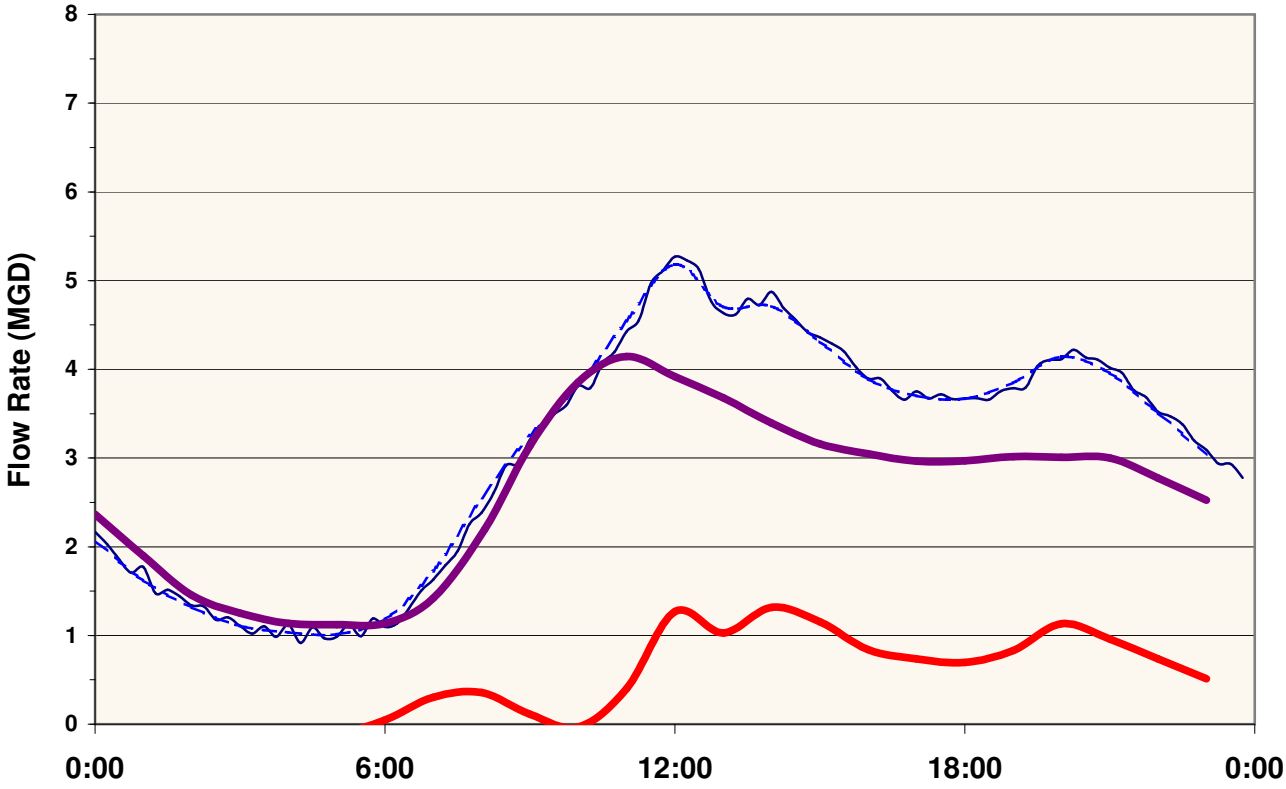


Encina Flow Meter Data

B2+V2 - FEB 7 Rain

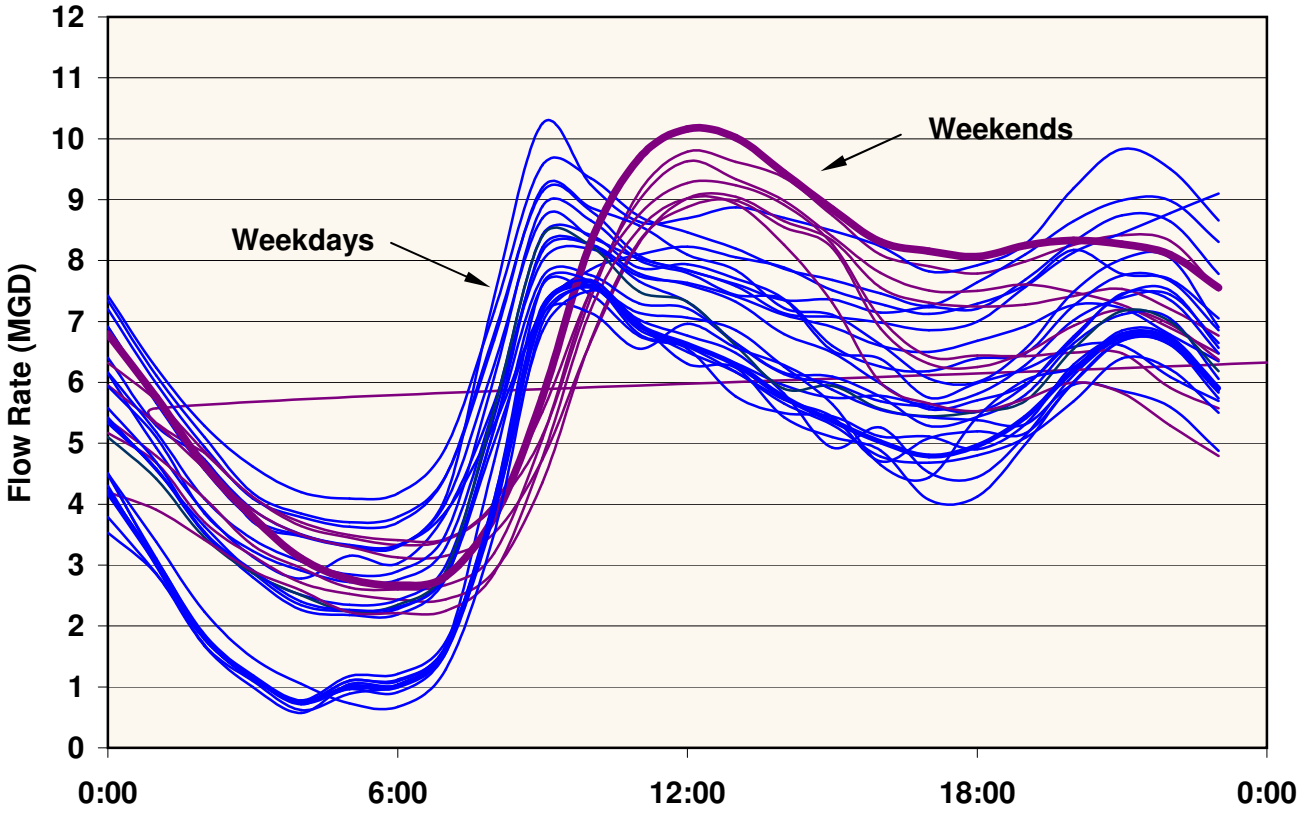


V2 + B2 - Mon Feb 16 (President's Day); Rain = 0.4"

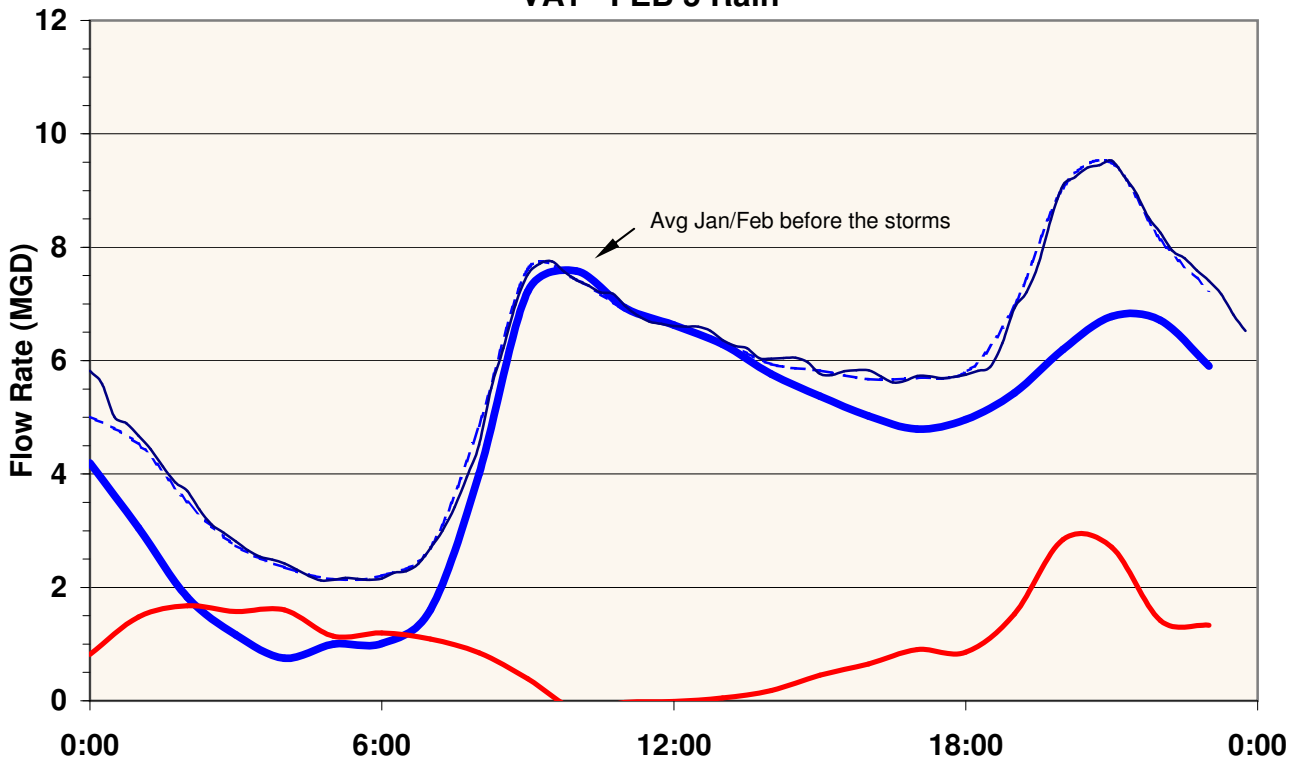


Encina Flow Meter Data

VA1 - Feb/09 Non-rain Days

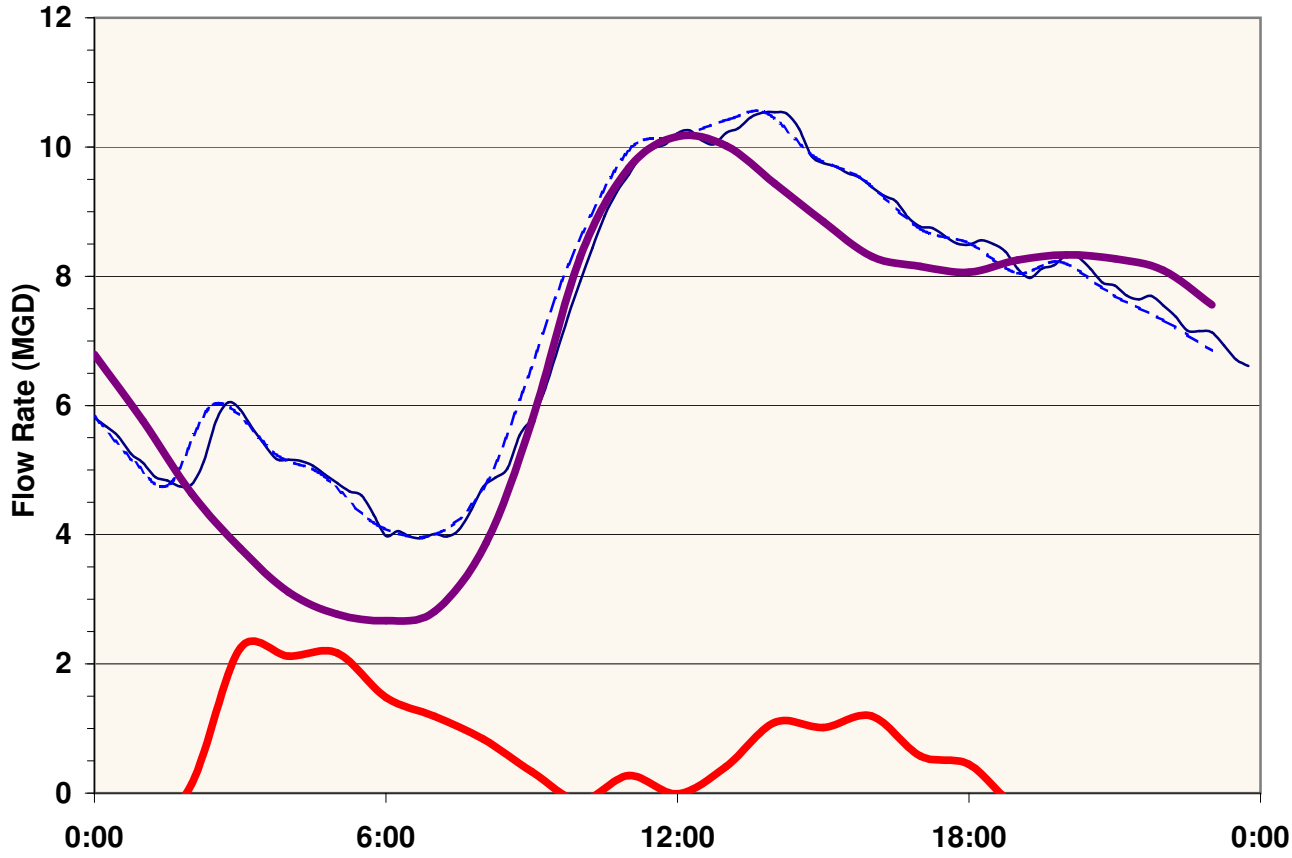


VA1 - FEB 5 Rain

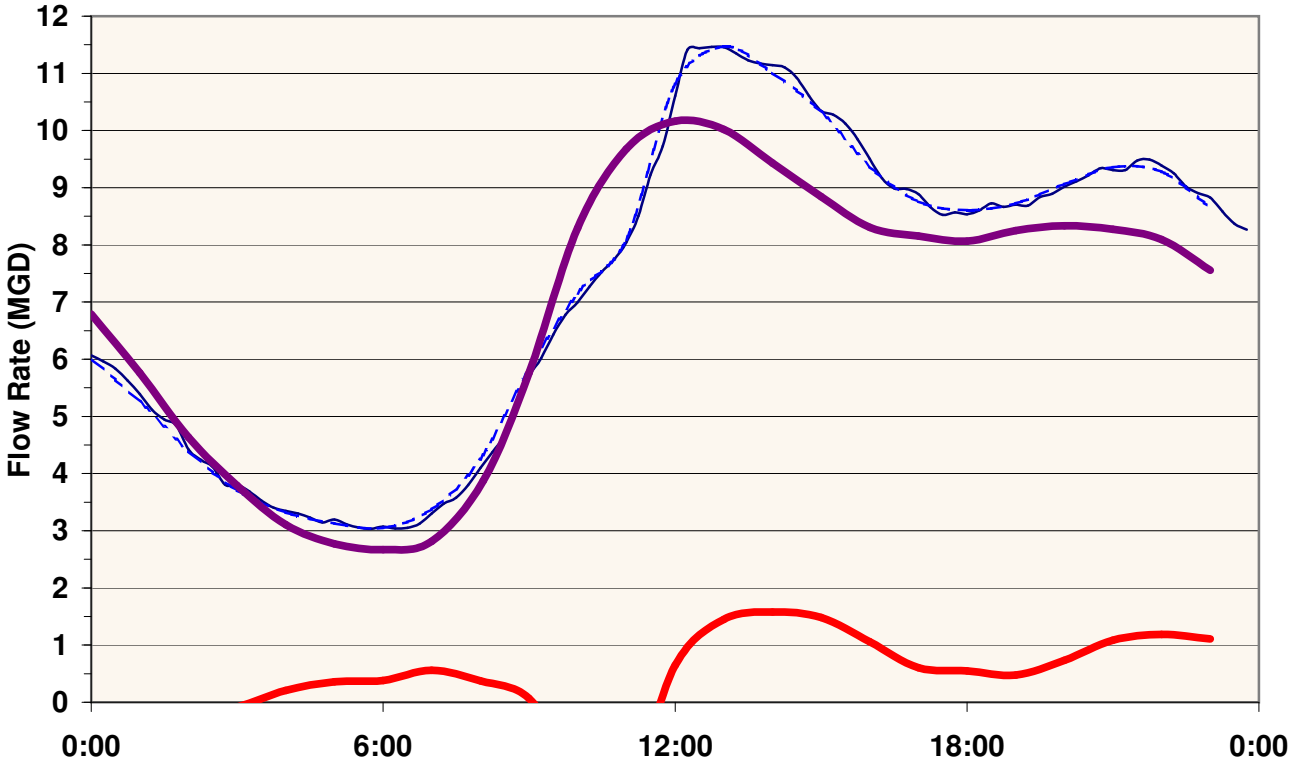


Encina Flow Meter Data

VA1 - FEB 7 Rain

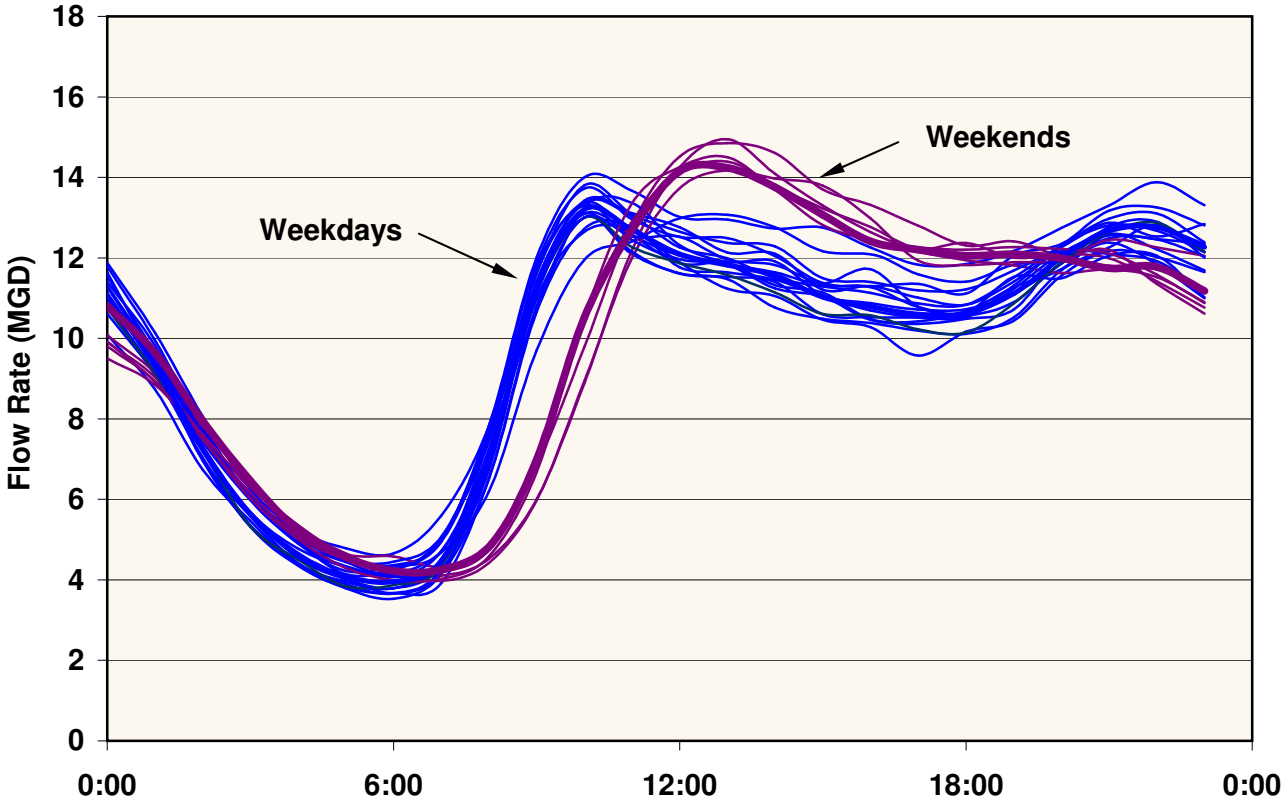


V1 - Mon Feb 16 (President's Day); Rain = 0.4"

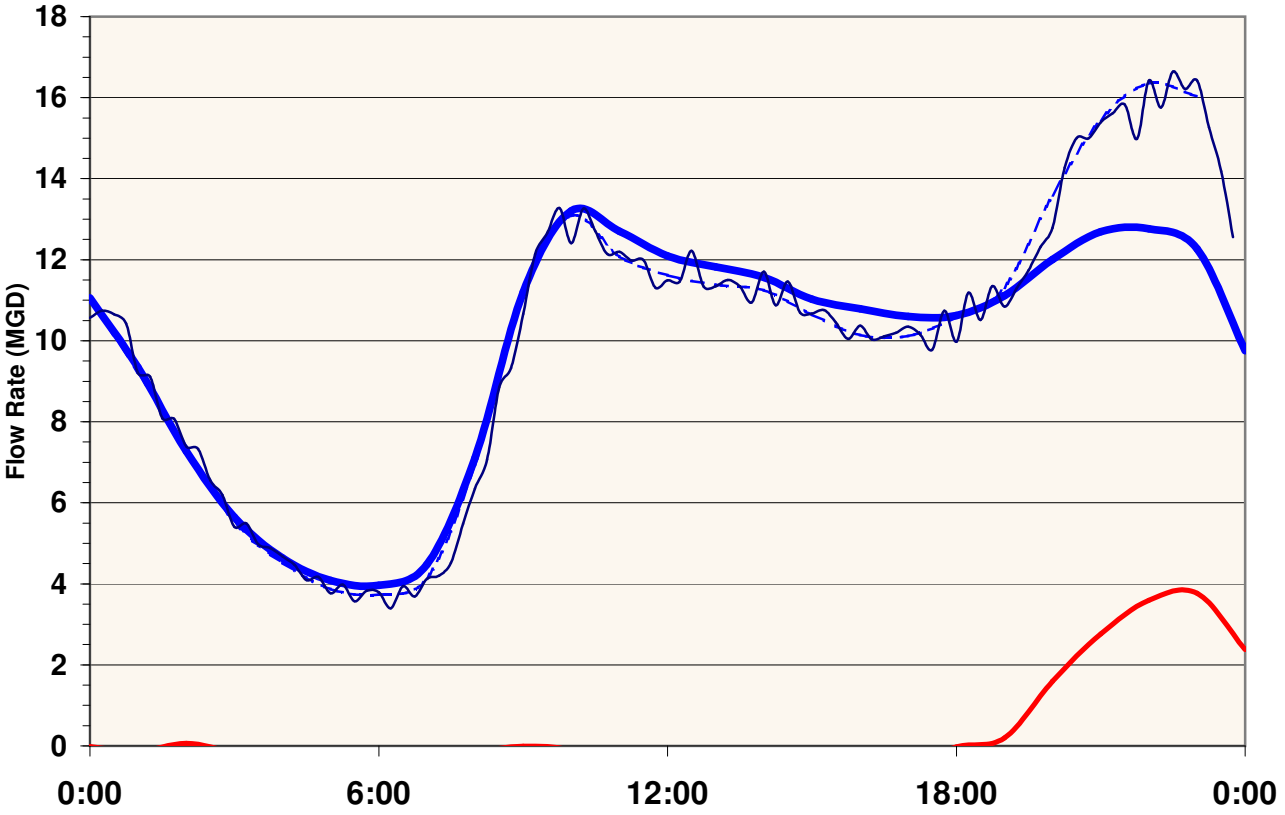


Encina Flow Meter Data

C3 - Feb/09 Non-rain Days

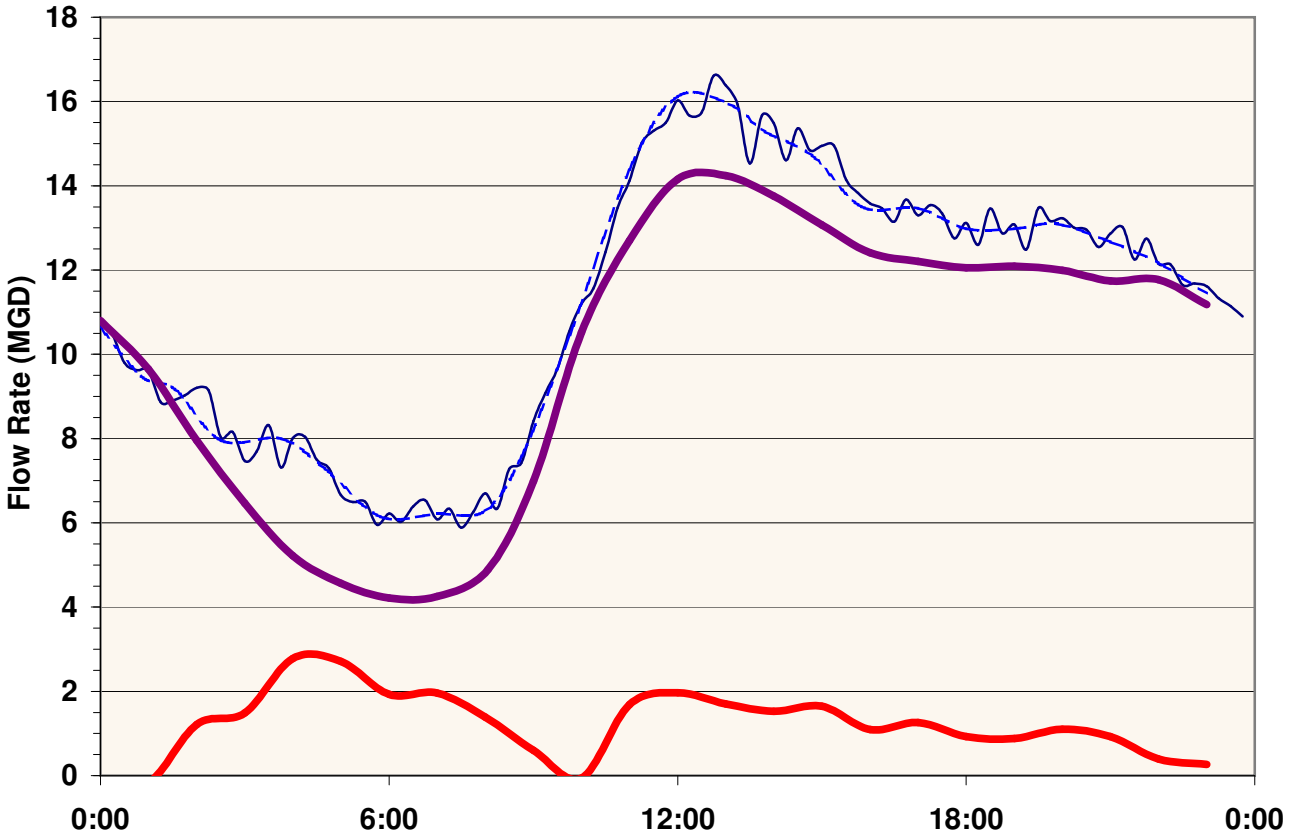


C3 - FEB 5 Rain

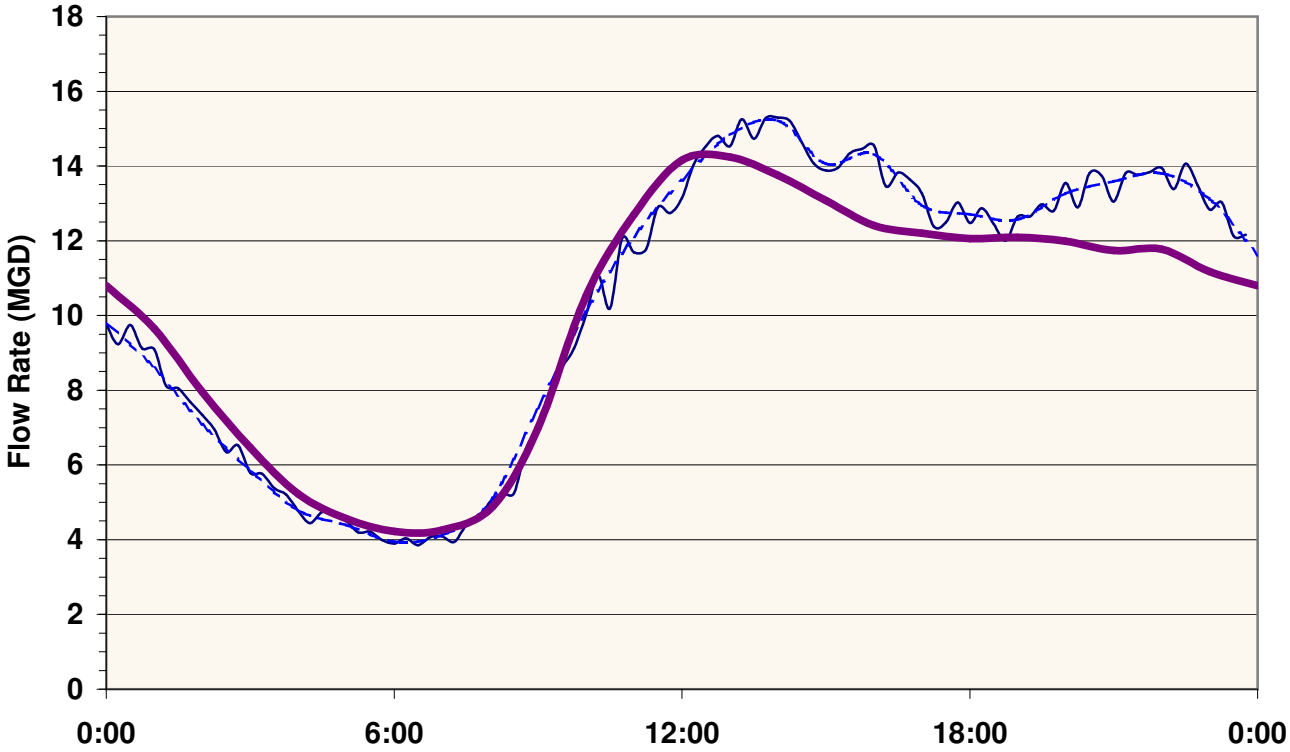


Encina Flow Meter Data

C3 - FEB 7 Rain

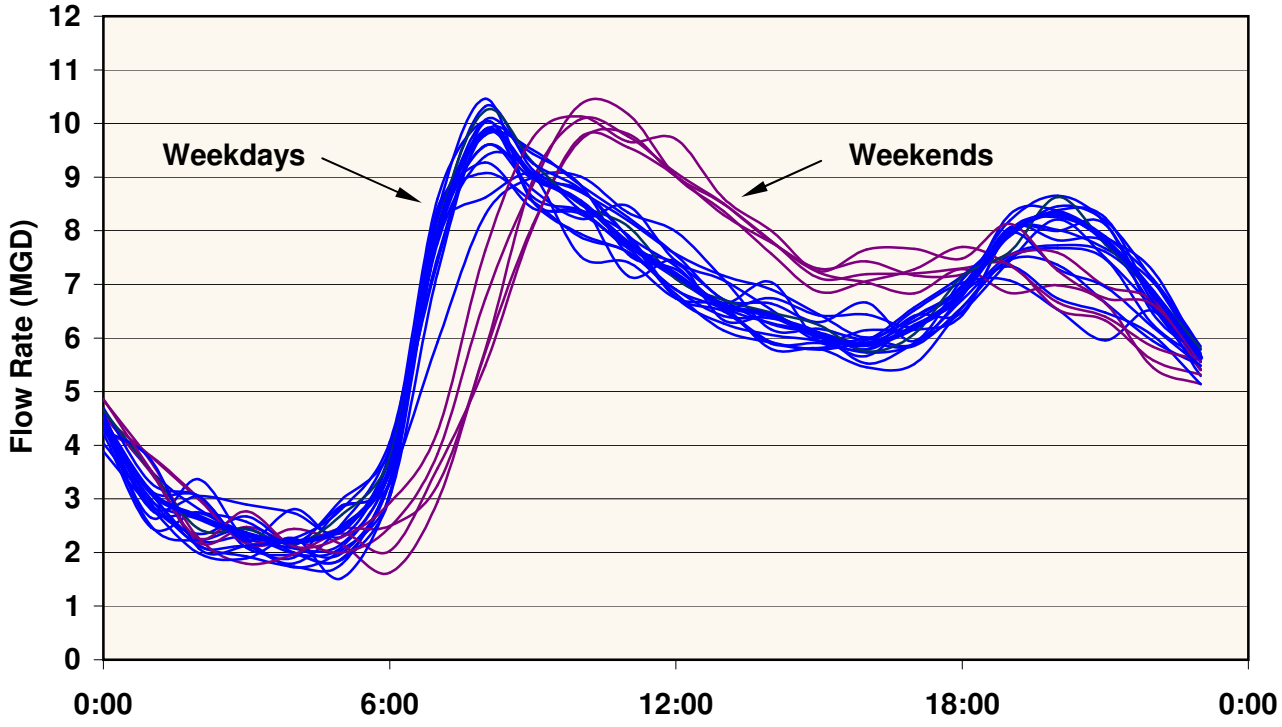


C3 - Mon Feb 16 (President's Day); Rain = 0.4"

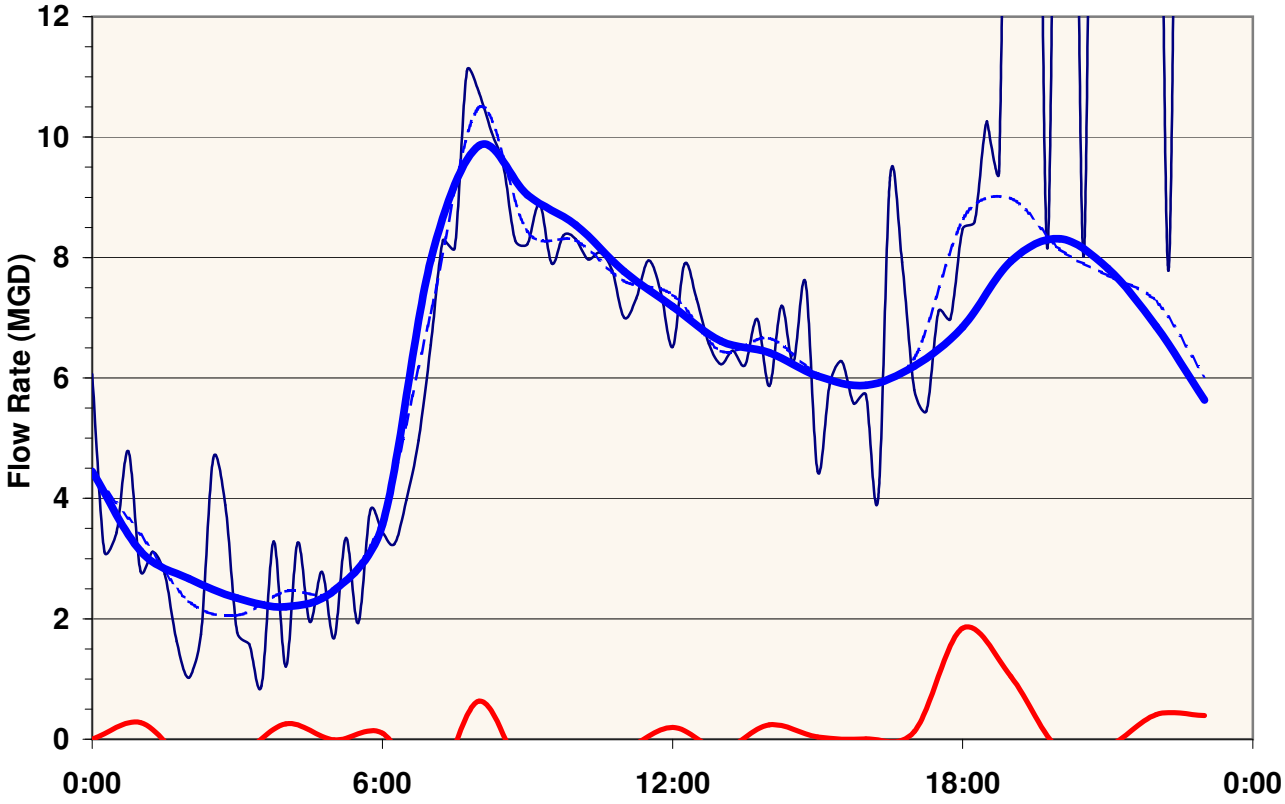


Encina Flow Meter Data

C2 - Feb/09 Non-rain Days

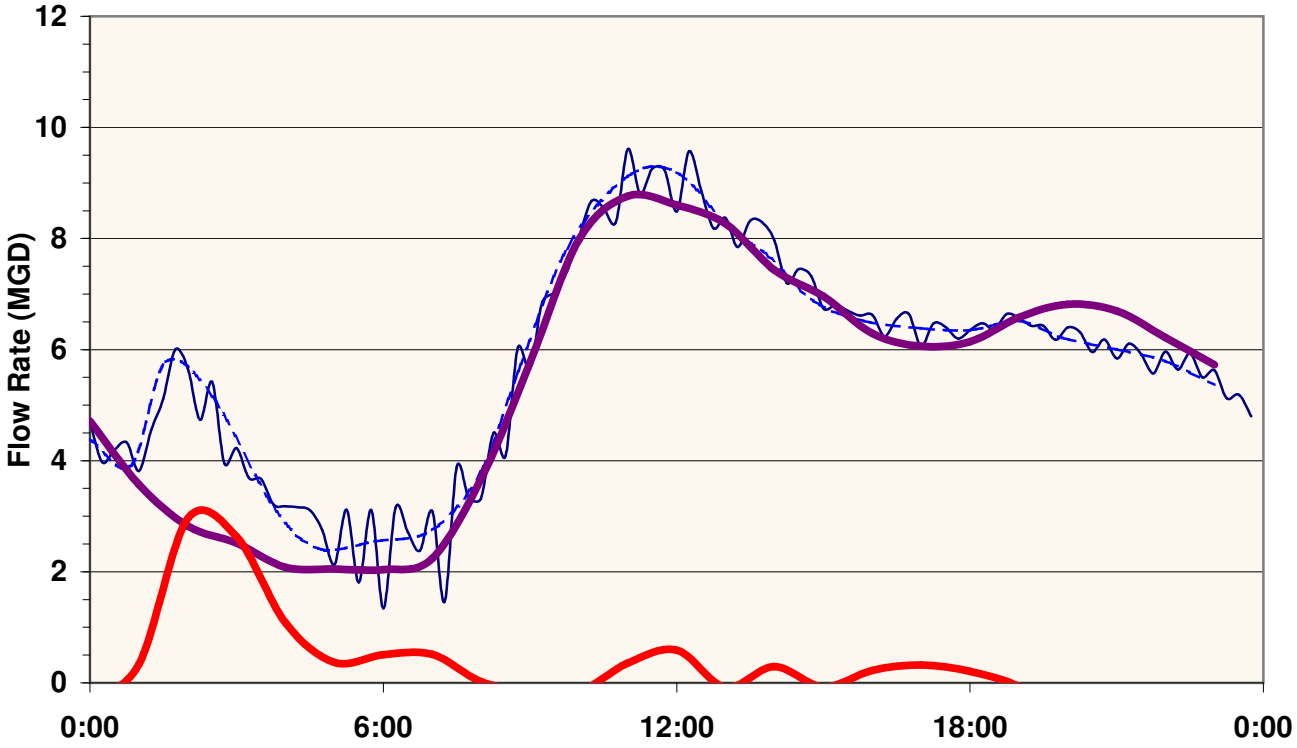


C2 - Thu Feb 5; Rain = 0.85"

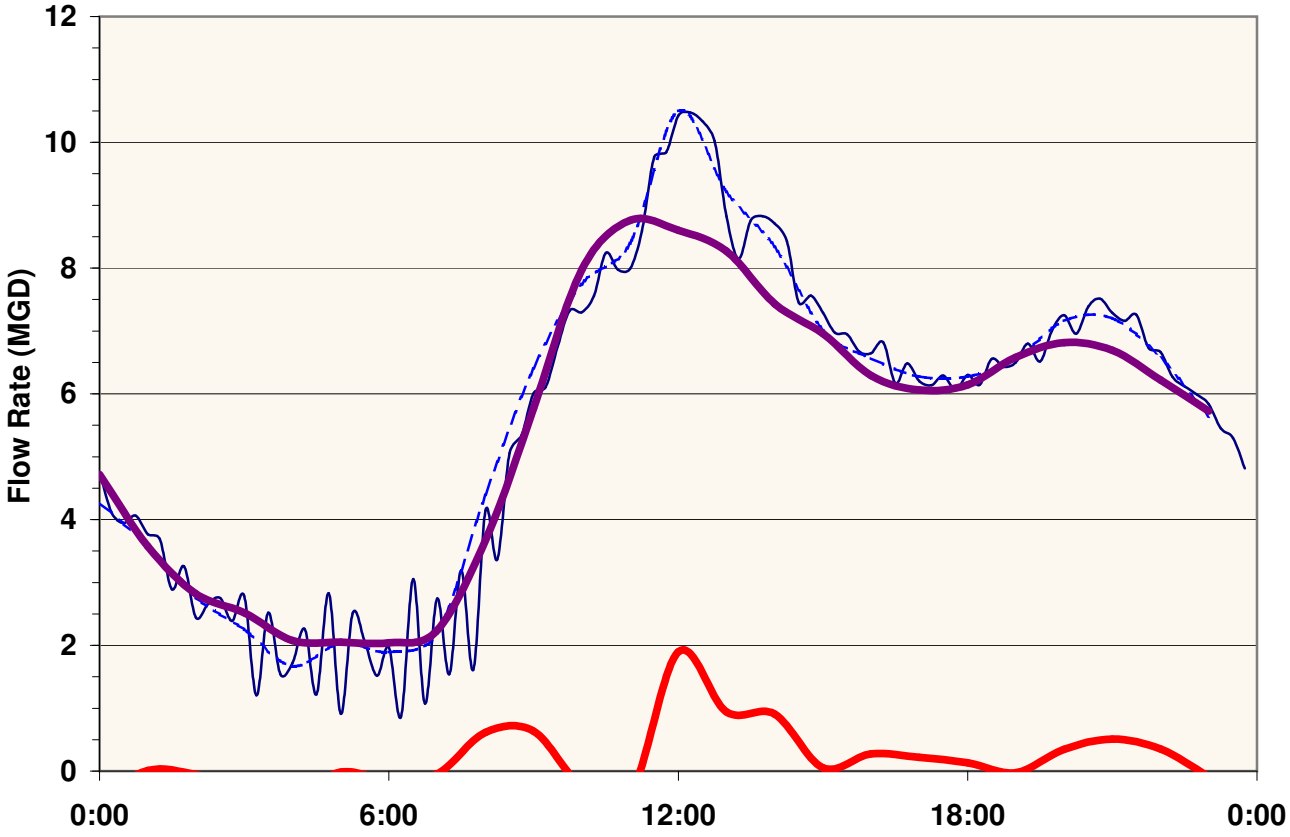


Encina Flow Meter Data

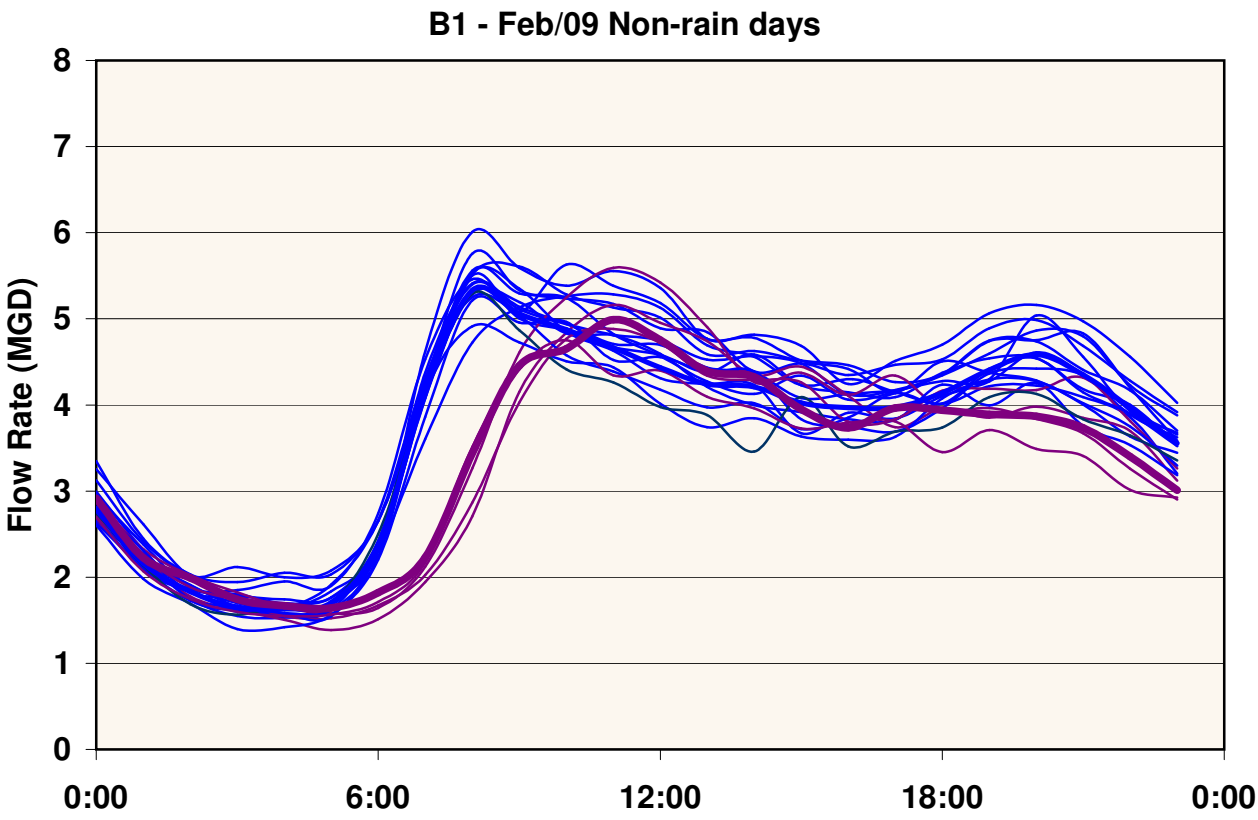
C2 - Sat Feb 7; Rain = 0.64"

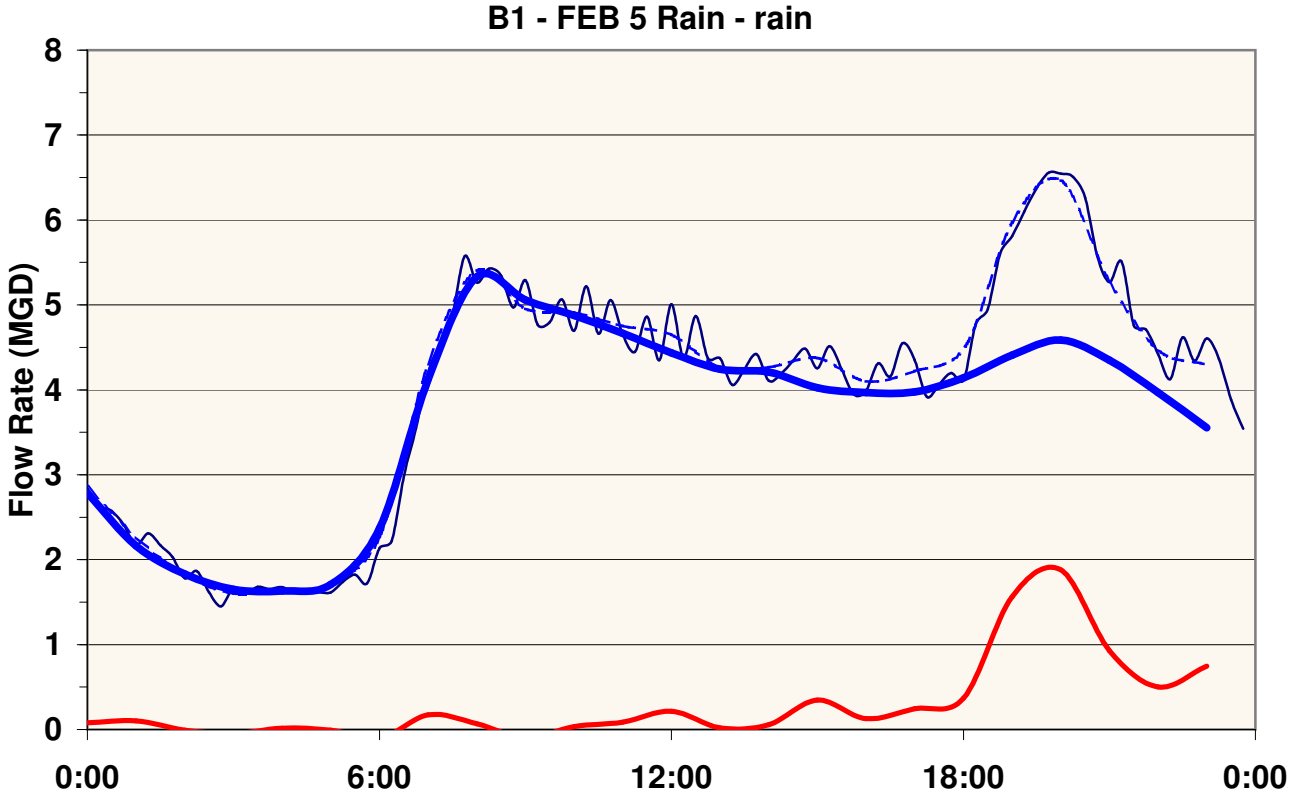


C2 - Mon Feb 16 (President's Day); Rain = 0.61"

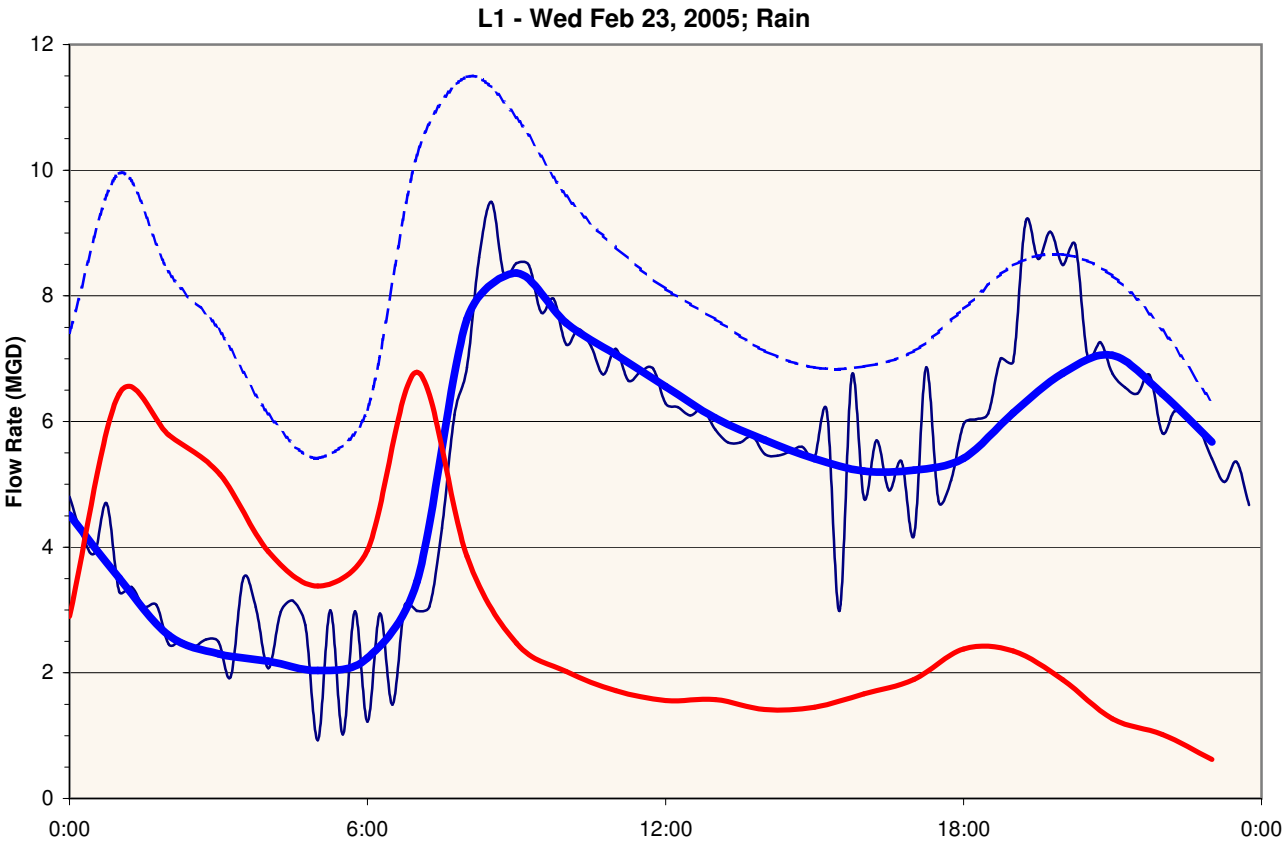


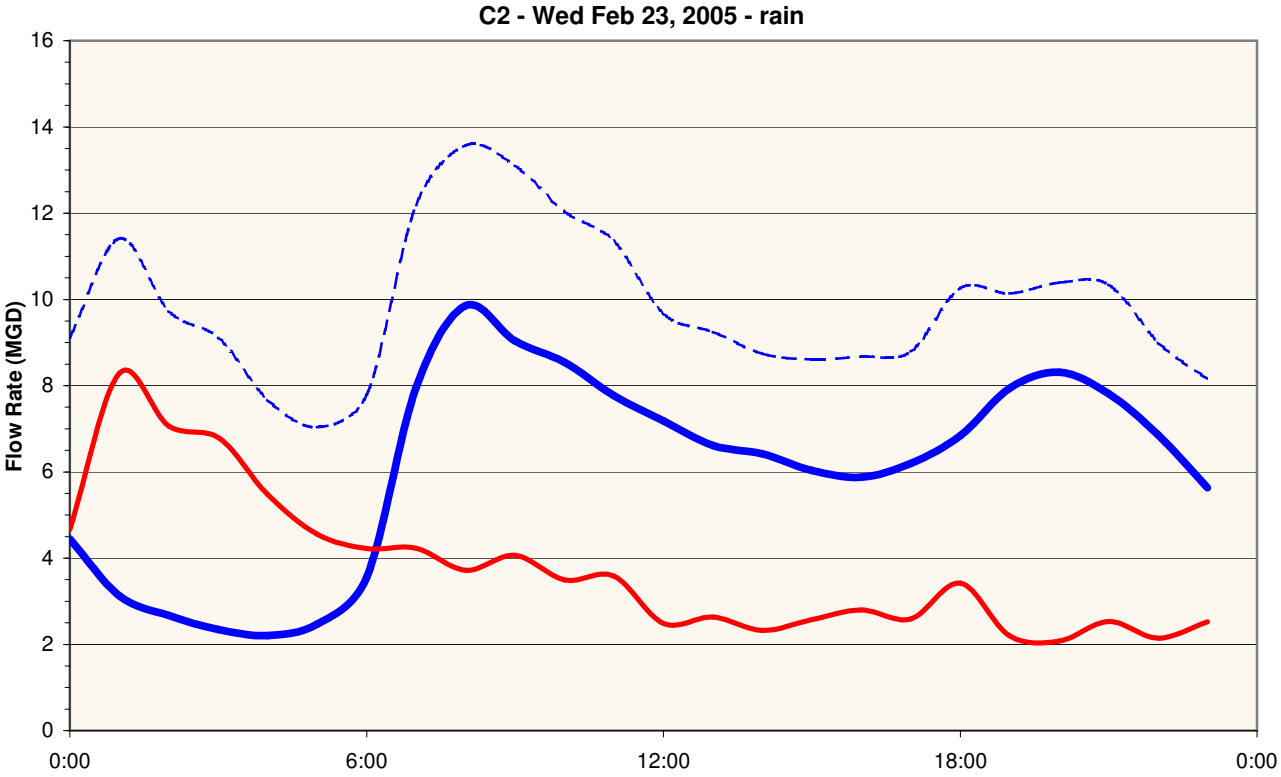
Encina Flow Meter Data

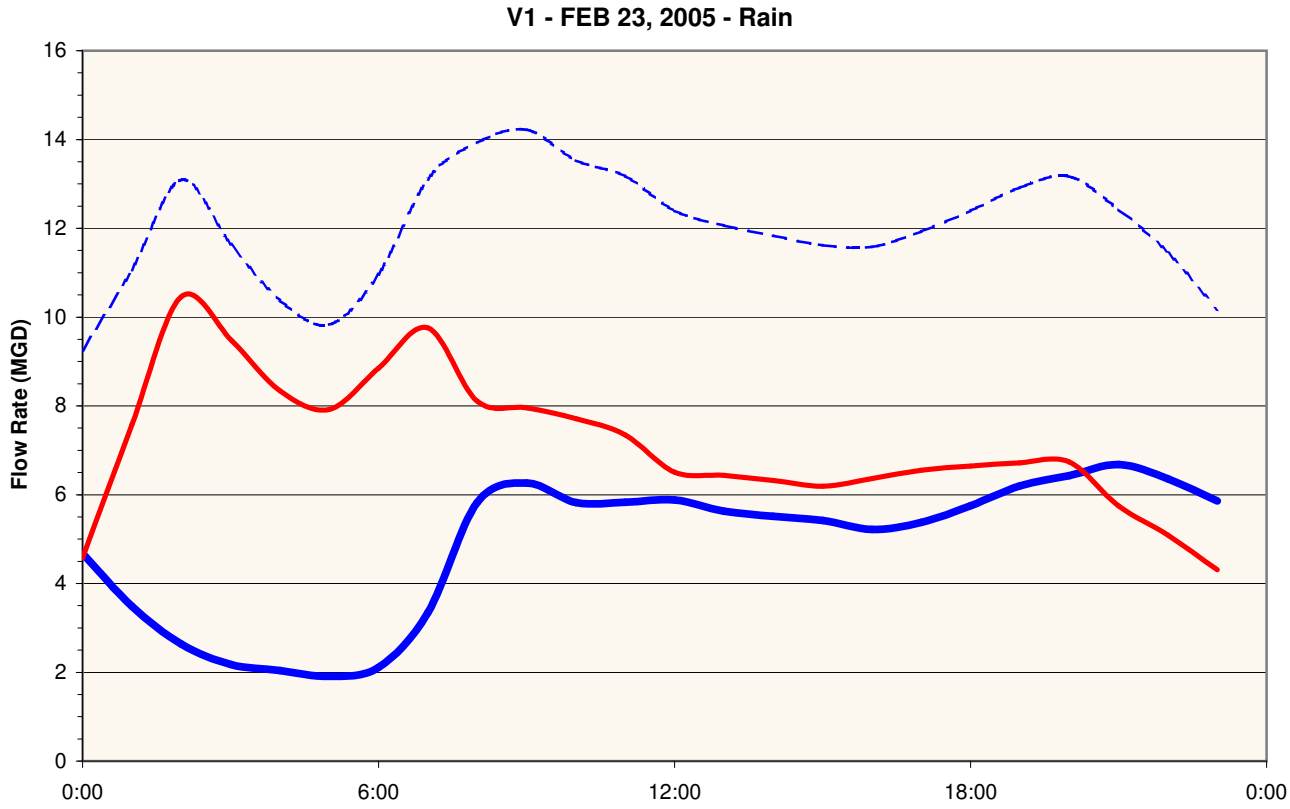


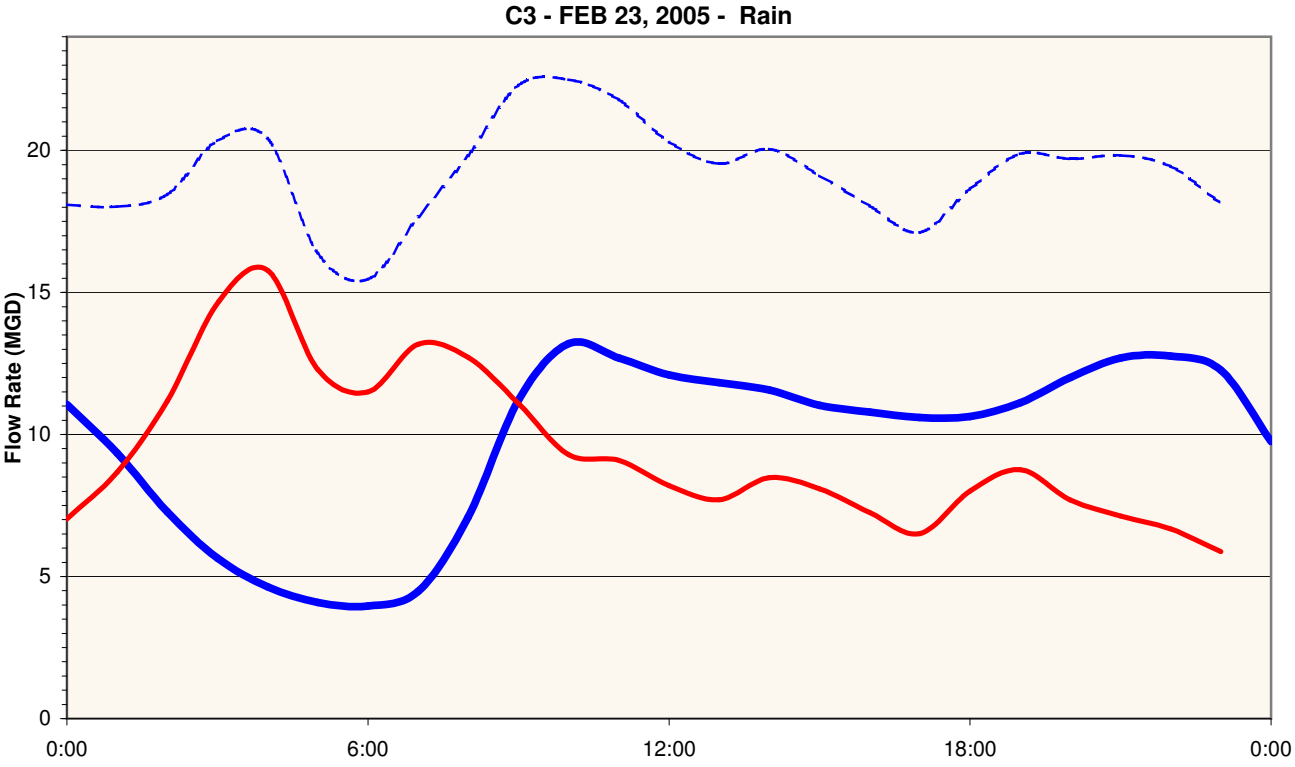


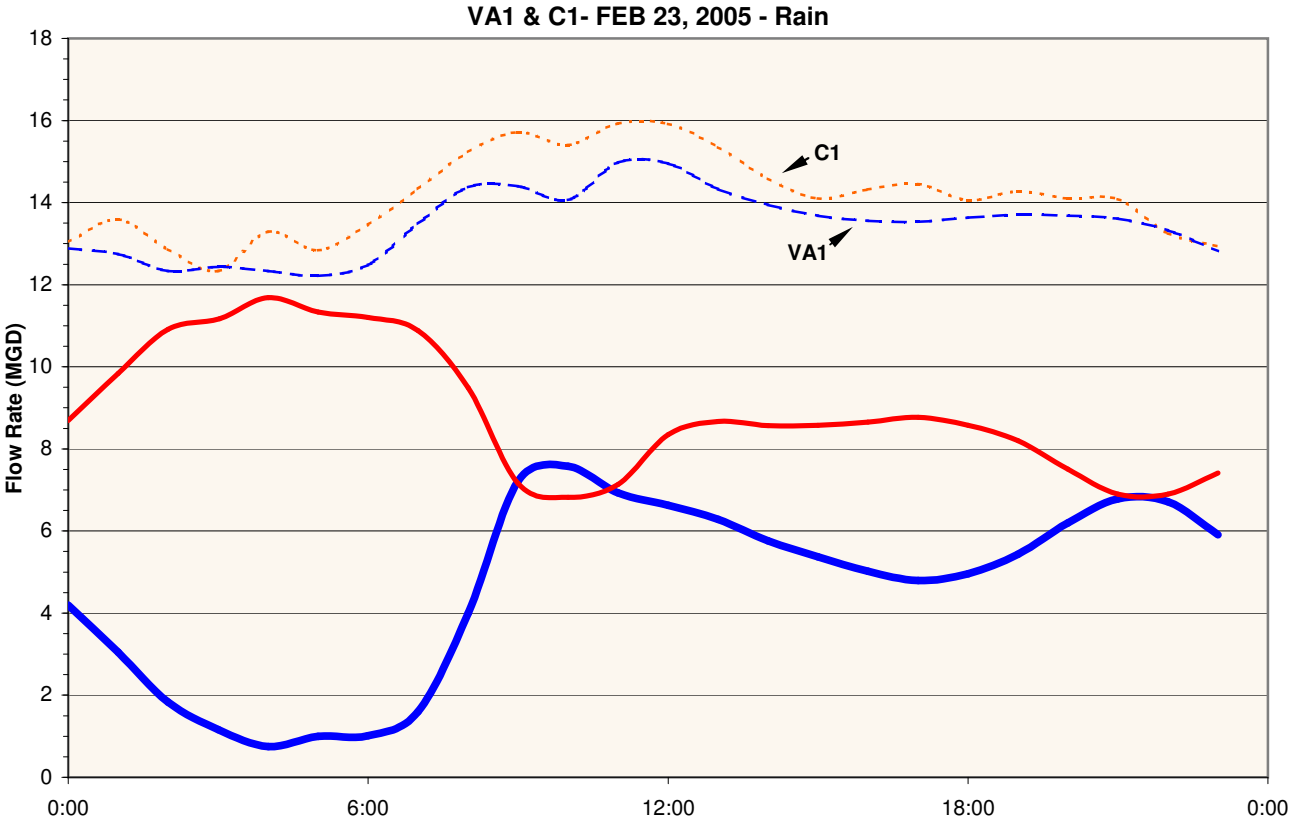
February 23, 2005 Graphs and I&I Flows

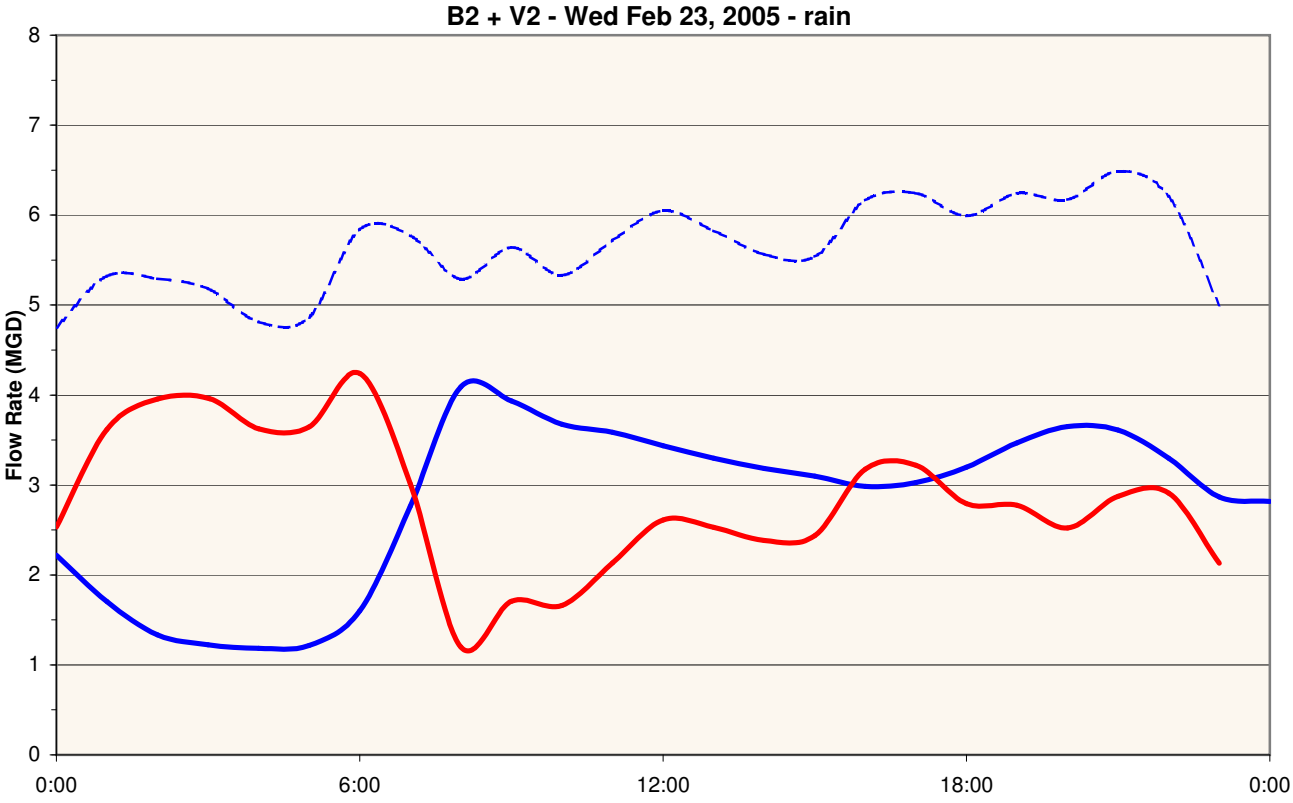

L1 - Wed Feb 23, 2005; Rain
Flow Rate (MGD)
12
10
8
6
4
2
0
0:00
6:00
12:00
18:00
0:00

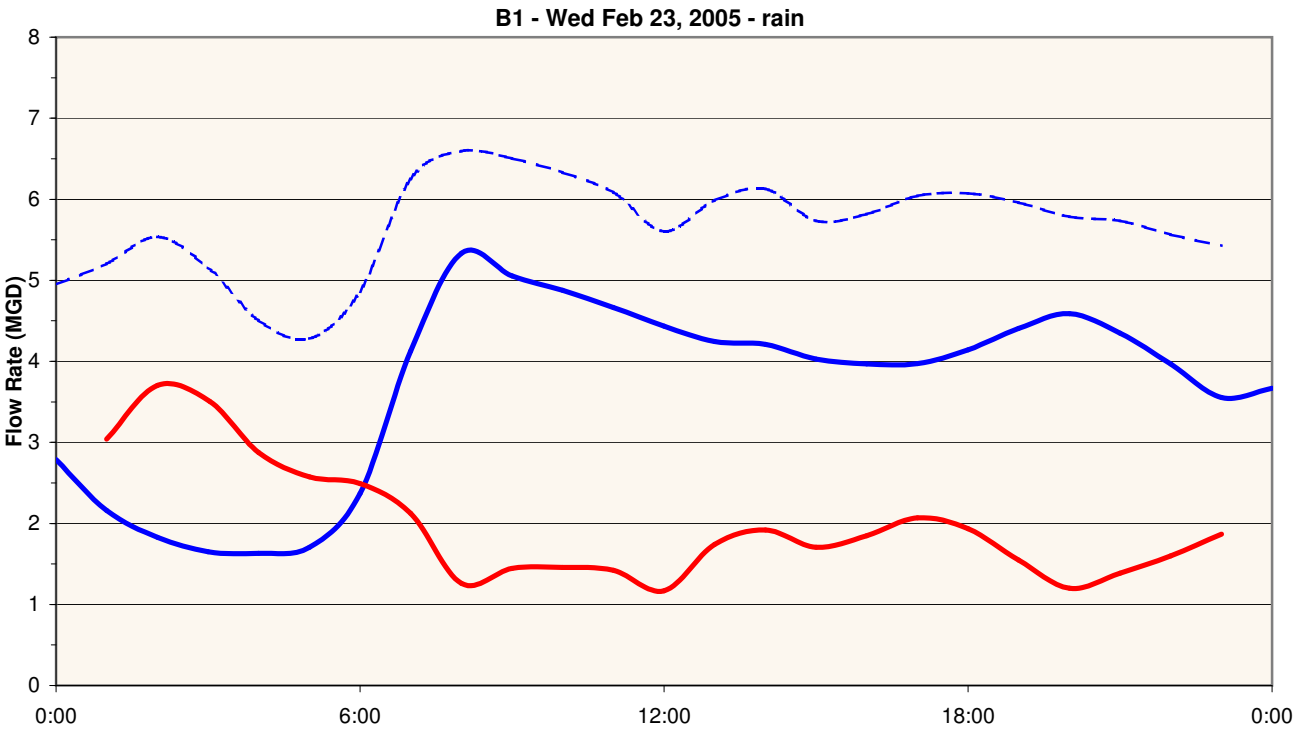

C2 - Wed Feb 23, 2005 - rain
Flow Rate (MGD)
16
14
12
10
8
6
4
2
0
0:00
6:00
12:00
18:00
0:00


V1 - FEB 23, 2005 - Rain
Flow Rate (MGD)
16
14
12
10
8
6
4
2
0
0:00
6:00
12:00
18:00
0:00


C3 - FEB 23, 2005 - Rain
Flow Rate (MGD)
20
15
10
5
0
0:00
6:00
12:00
18:00
0:00

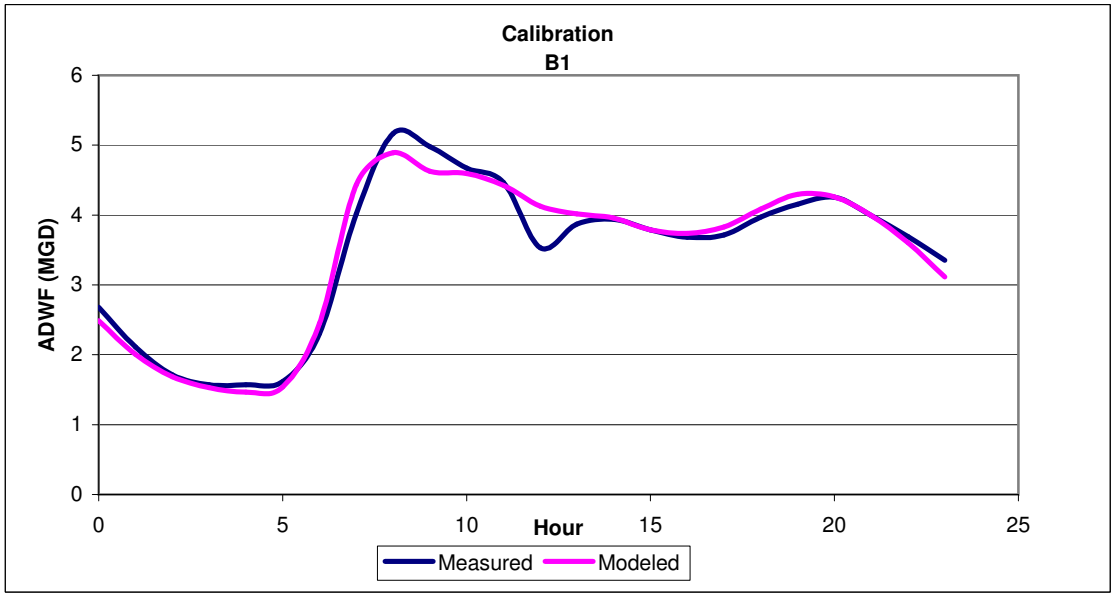

VA1 & C1- FEB 23, 2005 - Rain
Flow Rate (MGD)
18
16
14
12
10
8
6
4
2
0
C1
VA1
0:00
6:00
12:00
18:00
0:00

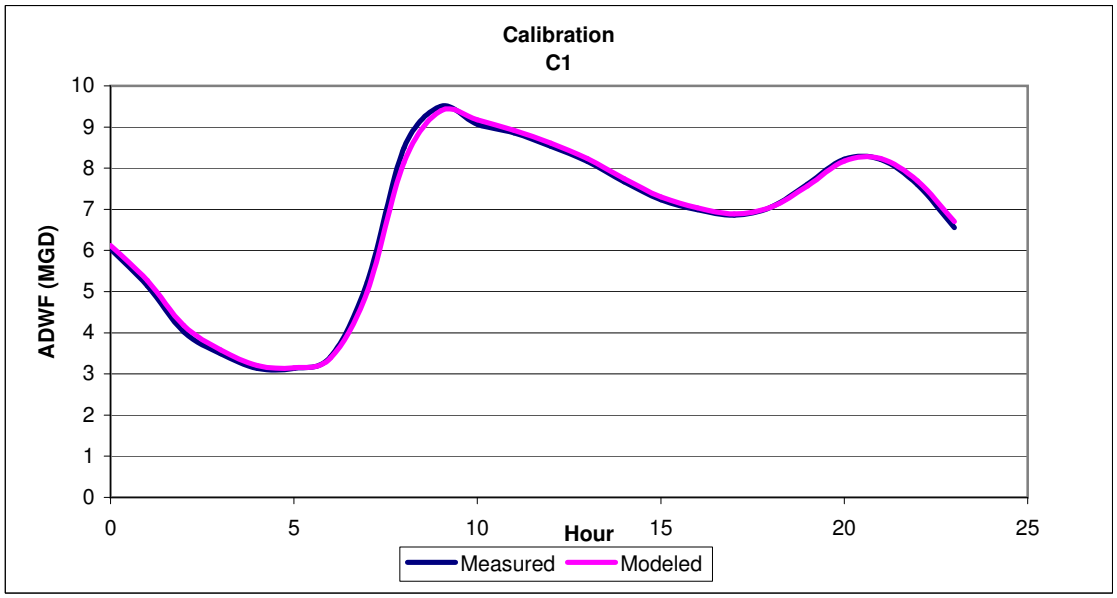

B2 + V2 - Wed Feb 23, 2005 - rain
Flow Rate (MGD)
8
7
6
5
4
3
2
1
0
0:00
6:00
12:00
18:00
0:00

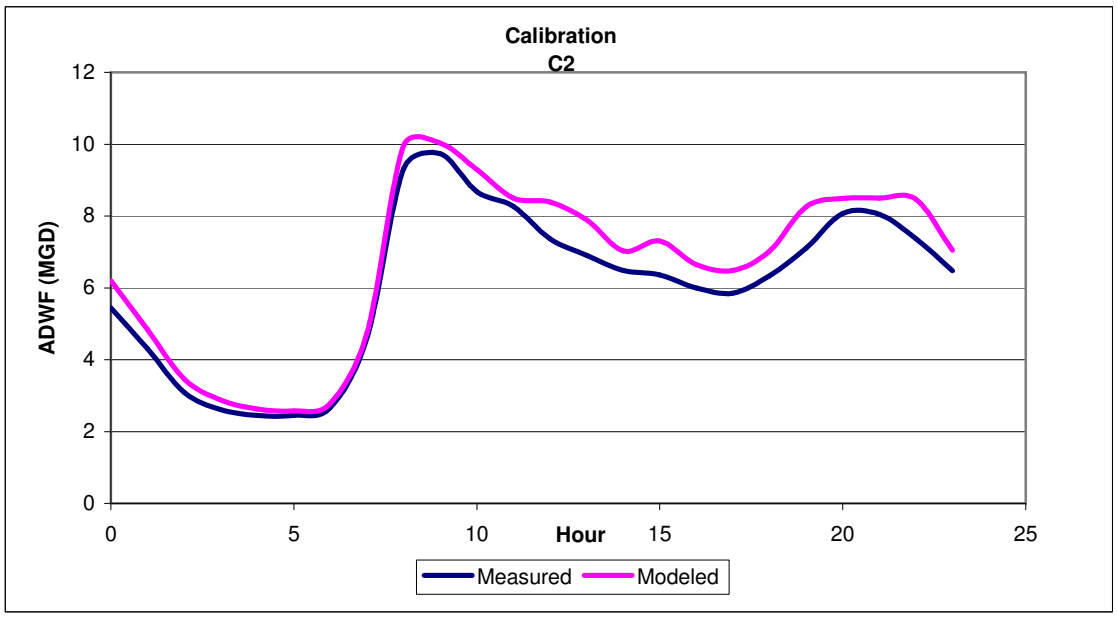

B1 - Wed Feb 23, 2005 - rain
Flow Rate (MGD)
8
7
6
5
4
3
2
1
0
0:00
6:00
12:00
18:00
0:00

Model Verification Flow Charts

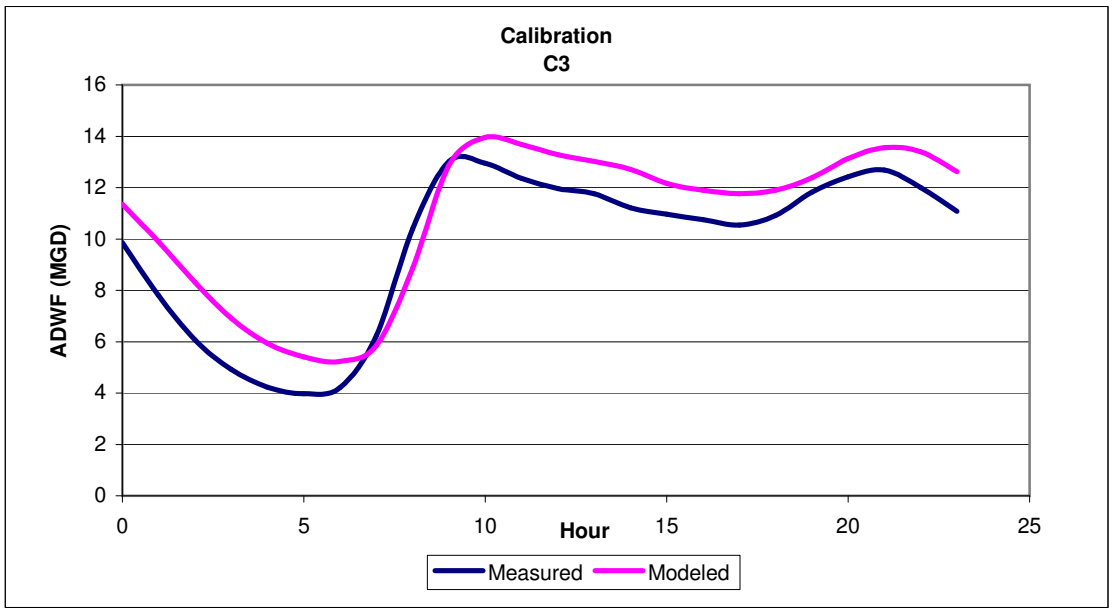
Model Verification Results - Feb 2009 flow data

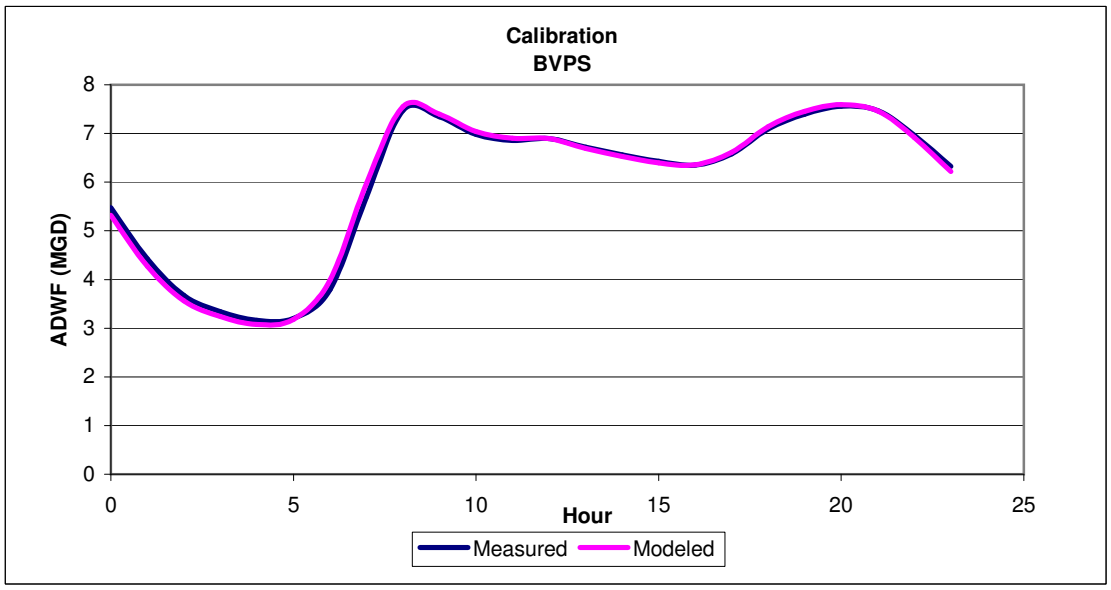


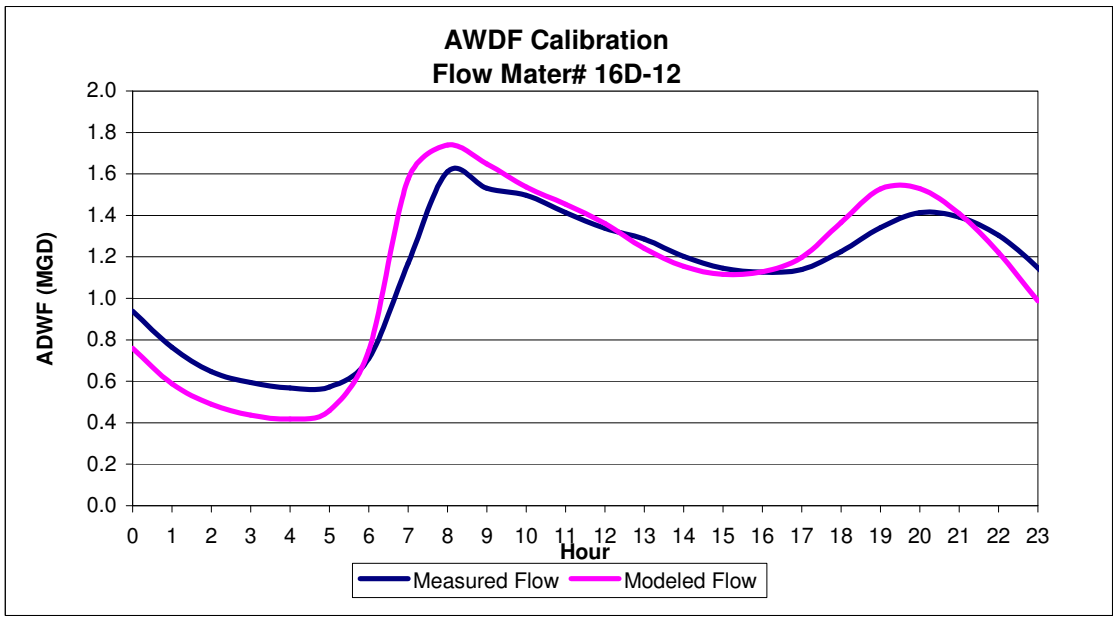




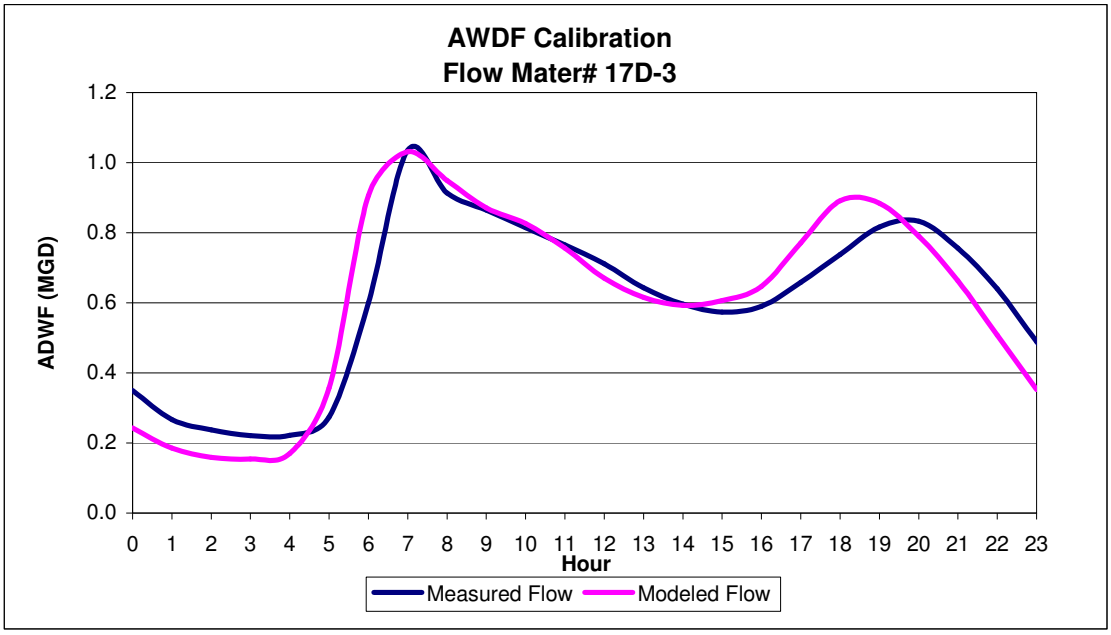
Model Verification Results - Feb 2009 flow data

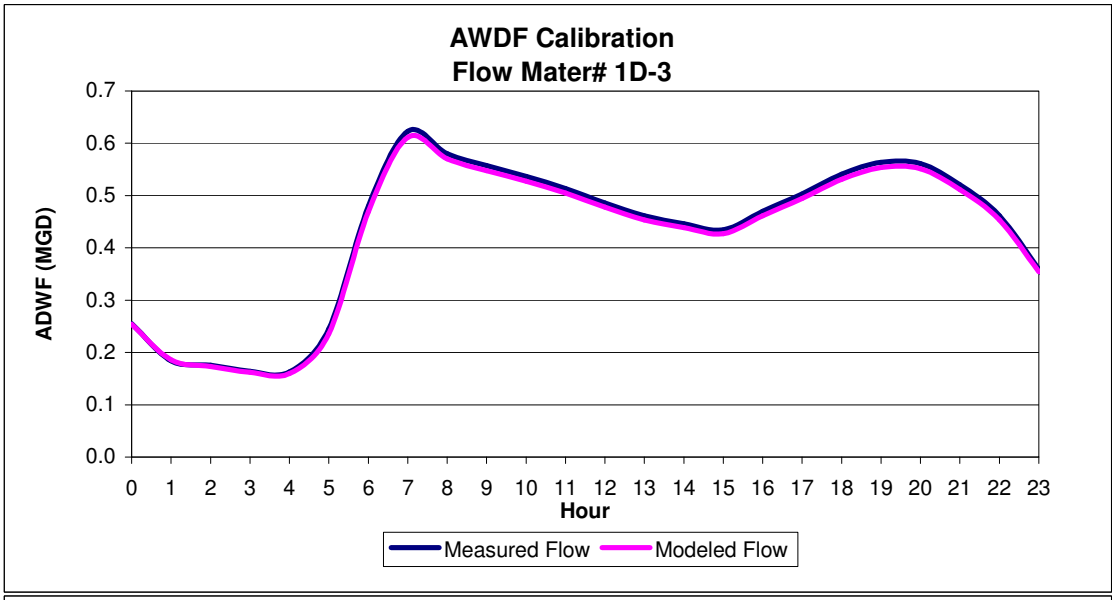


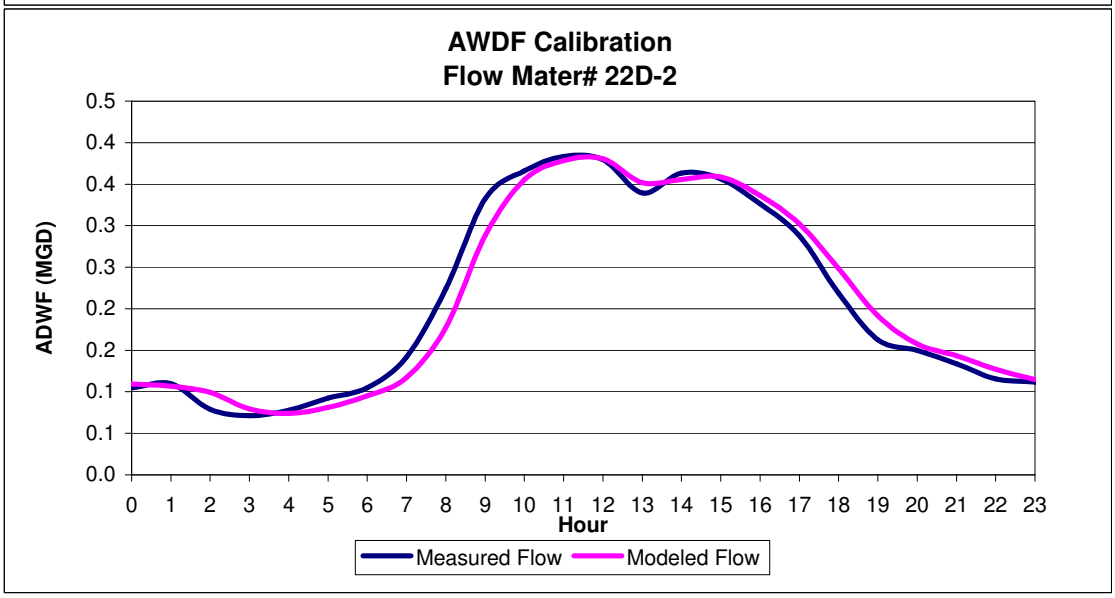




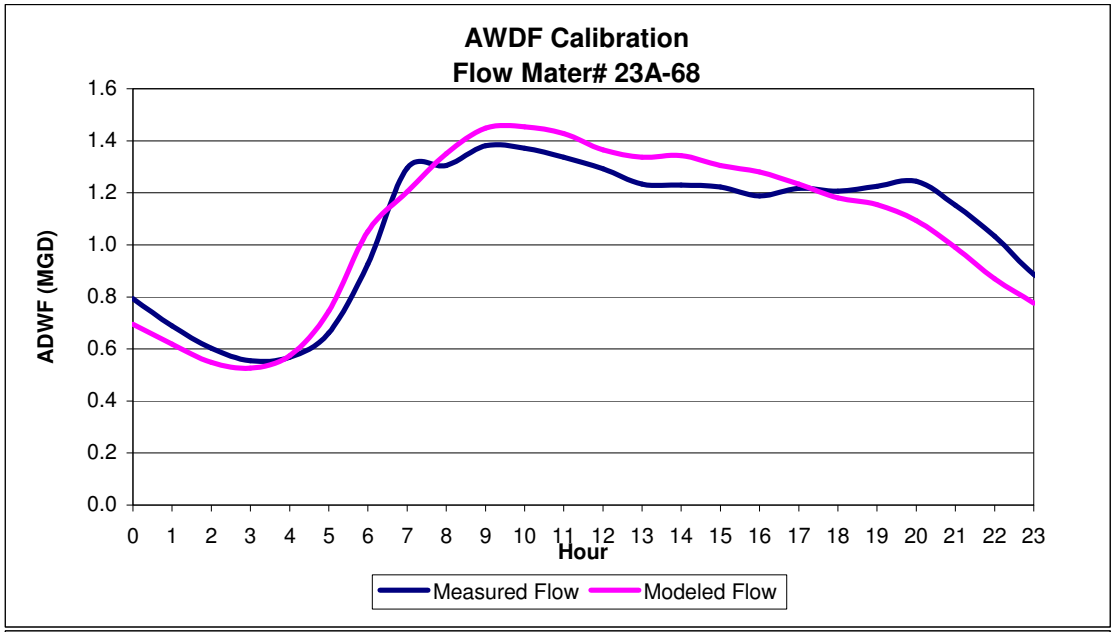
Model Verification Results - Feb 2009 flow data

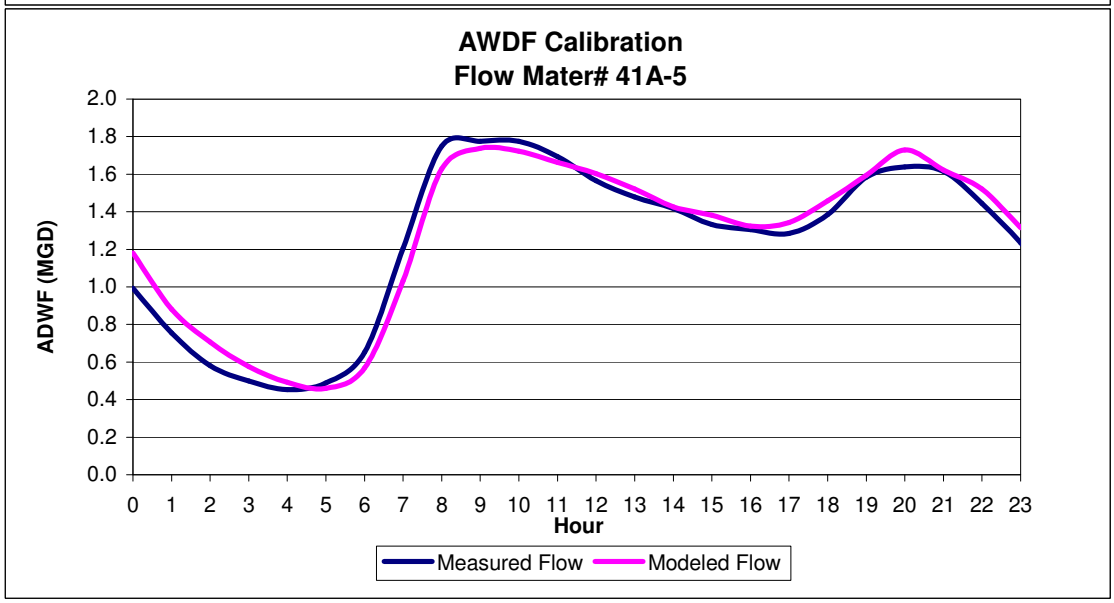


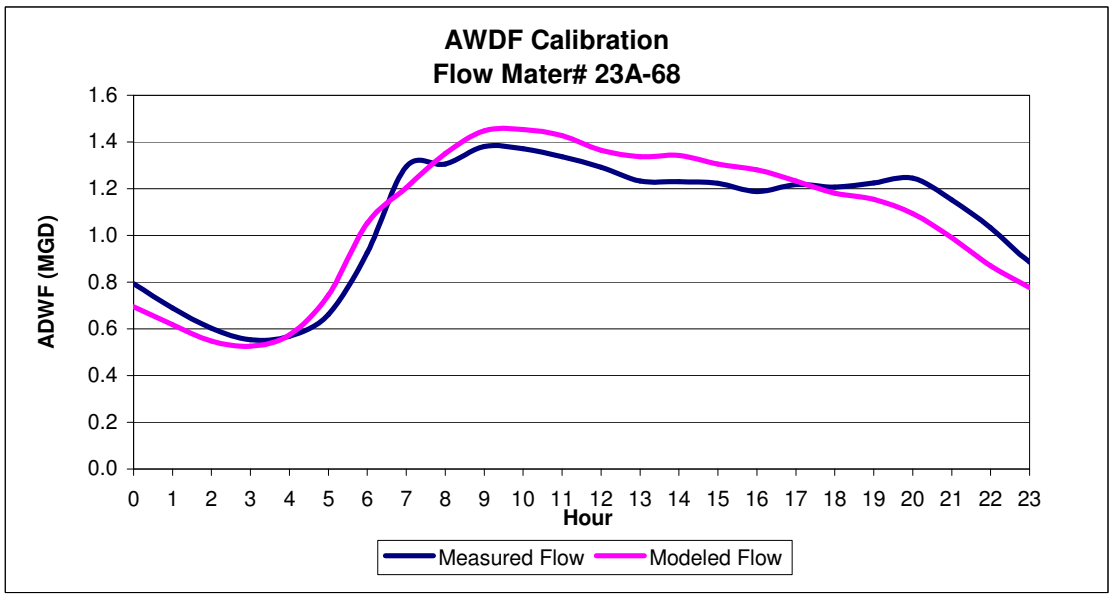




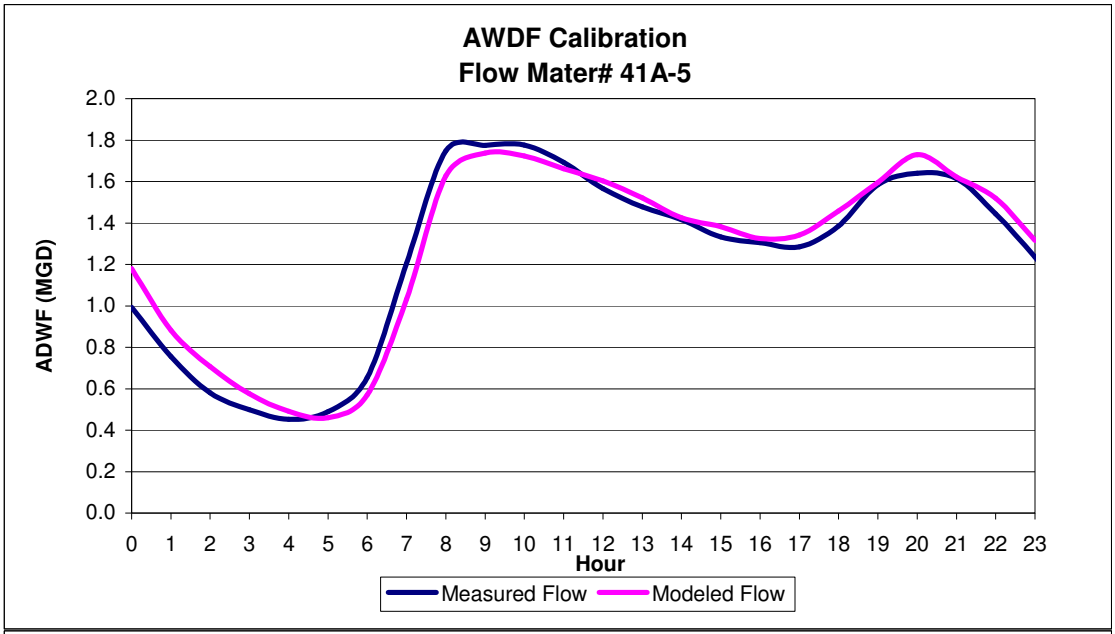
Model Verification Results - Feb 2009 flow data

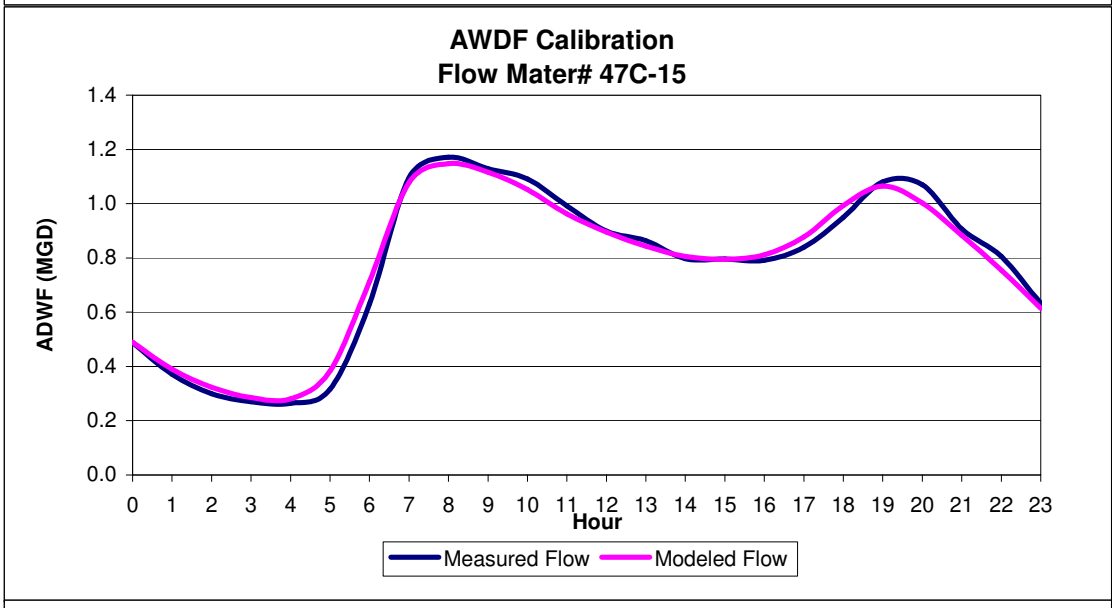


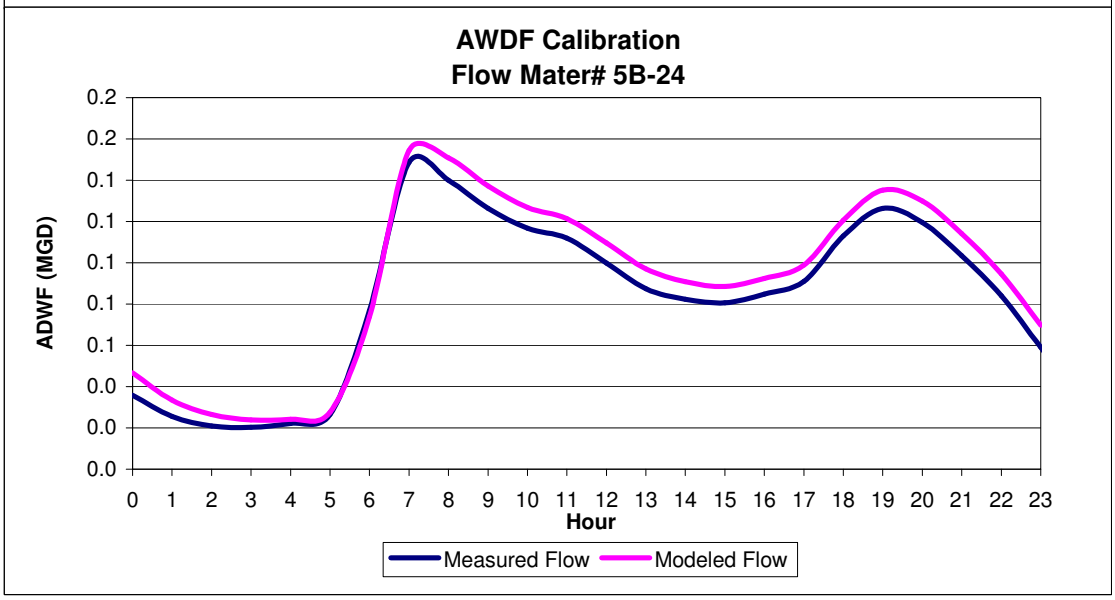




Model Verification Results - Feb 2009 flow data







Model Verification Results - Feb 2009 flow data